Radiological Health Data

VOLUME III, NUMBER 10

OCTOBER 1962

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Except where material is directly quoted or otherwise credited, summaries and abstracts are prepared by the Radiological Health Data and Reports Staff, Division of Radiological Health. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Health, Education, and Welfare
Atomic Energy Commission
Department of Defense
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Department of Commerce

For further information on any subject reported in this issue, readers are referred to the contributors indicated in the headings of the articles.

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RADIOLOGICAL HEALTH DATA

VOLUME III, NUMBER 10
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

ADVANCE REPORT

Reports received by the Public Health Service Radiation Surveillance Center for August and September 1962 have indicated fresh fallout from both U. S. and U.S.S.R. testing. The Service's Pasteurized Milk Network reports show daily levels of radioactive iodine-131 from July Nevada tests declined in Salt Lake City milk from 730 to 100 $\mu\mu$c per liter in August. The August Salt Lake City monthly average was 330 $\mu\mu$c/1. The only other station with an iodine-131 August monthly average over 40 $\mu\mu$c/1 was Laramie, Wyoming with 160 $\mu\mu$c/1. The September monthly iodine-131 averages for both Salt Lake City, Utah and Laramie, Wyoming were 40 $\mu\mu$c/1.

Apparent effects of the U.S.S.R. nuclear tests appeared in September when the Pasteurized Milk Network monthly tabulation of 62 stations showed an average daily iodine-131 concentration of 60 $\mu\mu$c/1 compared to the August average of 20 $\mu\mu$c/1. During September the monthly averages of 40 stations were above 20 $\mu\mu$c/1 compared to 6 stations in August. Of these 40, the following 9 stations, all in the northern States, had September monthly averages of 100 $\mu\mu$c/1 or more:

	$\mu\mu$c/l		$\mu\mu$c/l
Palmer, Alaska	730	Buffalo, New York	100
Chicago, Illinois	100	Minot, North Dakota	170
Des Moines, Iowa	120	Rapid City, South Dakota	130
Detroit, Michigan	120	Milwaukee, Wisconsin	120

SECTION I.—AIR AND PRECIPITATION

Fission Product Beta Activity in Airborne Particulates and Precipitation

Measurements of gross beta activity of airborne particulates and precipitation are among the earliest and most sensitive indicators of increases of fission product activity in the environment. However, a direct evaluation of biological effects is not possible from these data alone.

Of the several networks or sampling programs making such measurements, the Radiation Surveillance Network, the Naval Research Laboratory, the National Air Sampling Network, and the Canadian Radioactive Fallout Study Program are represented in the following reports.

RADIATION SURVEILLANCE NETWORK July 1962

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network (RSN) was established in 1956 in cooperation with the Atomic Energy Commission primarily to provide a means of promptly determining increasing levels of radioactivity in air and precipitation due to fallout from nuclear weapons tests. Prior to September 1961, the Network consisted of 45 stations. Following the September 1961 resumption of nuclear weapons testing by the U.S.S.R., the Network has been expanded over a period of several months to 72 stations, whose locations are shown in figure 1.

Air

Daily 24-hour air samples are collected by a high volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field measurements with a portable survey meter enable the station operator to estimate the amount of beta activity in airborne particulates at the station five hours after collection by comparison with a known Sr^{90}–Y^{90} source. This 5-hour delay eliminates interference from naturally-occurring radon daughters. Each operator then reports his field estimate by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C., to provide a daily national report.

The filters are then forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and recounted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day interval, make possible the estimation of the age of fission products and extrapolation of the

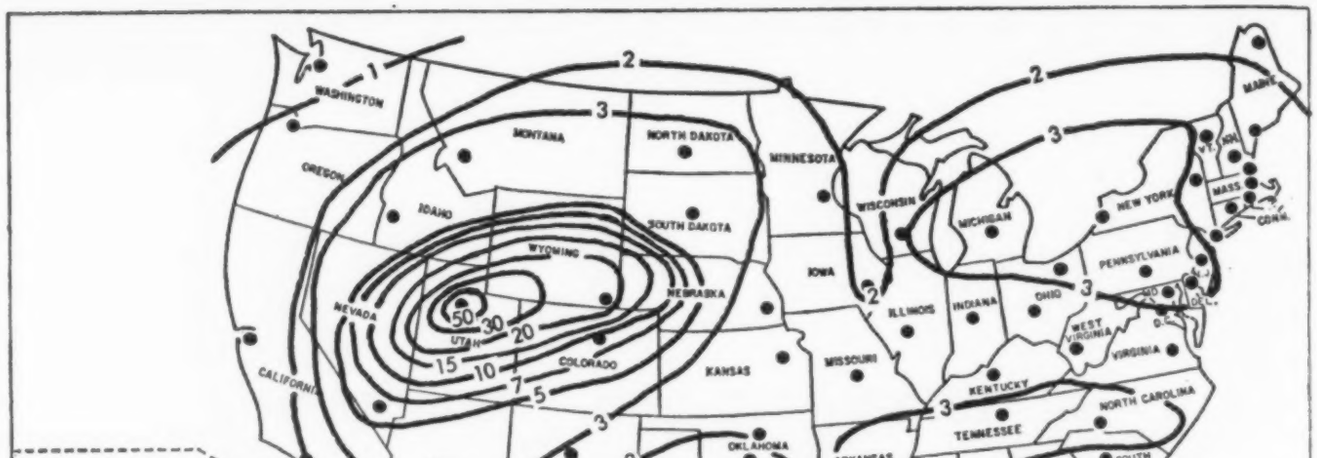


FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$) JULY 1962

activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant).*

Although gross beta concentration is usually presented without reference to age, it is apparent that fission product activity is more adequately described when the age parameter is also given. An example of the interpretative usefulness of age of fission product data is presented in "Mid-May Iodine–131 in Fallout in the Midwest" in *RHD*, September 1962, Section V. Because of the difficulty in determining a meaningful monthly average of age of fission products, such data have not yet been presented with the RSN data in *RHD*.

The average fission-product beta concentrations in surface air during July 1962 as determined by laboratory analysis are tabulated in table 1 and presented by means of concentration contours in figure 1. Experience has shown that field estimates are generally comparable to laboratory analyses, except at low levels, where the former are usually higher because of natural thoron daughters.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels having collection areas of 0.4 m^2. A 500 ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml (equivalent to 0.5 mm rainfall), the volume of precipitation is reported, but no analysis is made.

The June 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and millimicrocuries per square meter ($m\mu c/m^2$) are presented in table 2. Placement of a "less than" sign (<) with an average concentration or total deposition value indicates that the sum of the "less than" daily deposition values is 10 percent or more of the

* In this expression, A is the activity at time T after fission product formation. Units are arbitrary.

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, JULY 1962

[Concentrations in $\mu\mu c/m^3$]

Station location		Number samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average*
City	State				
Adak	Alaska	24	1.6	<0.10	0.40
Anchorage	Alaska	31	5.3	<0.10	1.1
Attu	Alaska	30	3.2	<0.10	0.50
Fairbanks	Alaska	16	2.7	<0.10	1.6
Juneau	Alaska	19	3.4	0.47	1.0
Kodiak	Alaska	31	2.9	<0.10	0.71
Nome	Alaska	28	4.7	<0.10	0.93
Point Barrow	Alaska	28	1.8	<0.10	0.43
St. Paul Island	Alaska	16	1.1	<0.10	0.31
Phoenix	Ariz	30	14	1.2	3.1
Little Rock	Ark	31	12	1.1	3.3
Berkeley	Calif	31	2.5	0.17	1.2
Los Angeles	Calif	23	3.1	0.84	2.0
Denver	Colo	31	93	1.3	7.3
Hartford	Conn	31	2.5	0.61	2.5
Dover	Del	22	7.1	1.5	4.1
Washington	D. C	31	6.9	0.81	2.9
Jacksonville	Fla	31	5.5	0.72	2.4
Miami	Fla	31	3.4	0.90	1.6
Atlanta	Ga	31	4.8	0.47	2.5
Agana	Guam	13	19	<0.10	2.9
Honolulu	Hawaii	29	2.5	0.18	1.1
Boise	Idaho	28	25	2.1	4.2
Springfield	Ill	31	6.5	1.1	2.5
Indianapolis	Ind	30	4.5	0.83	2.4
Iowa City	Iowa	31	3.9	0.69	1.9
Topeka	Kans	31	5.9	0.94	2.3
Frankfort	Ky	29	4.9	0.93	2.1
New Orleans	La	31	5.7	0.82	2.5
Augusta	Maine	31	5.1	0.12	2.3
Presque Isle	Maine	25	3.7	0.15	1.4
Baltimore	Md	31	6.6	1.2	3.2
Rockville	Md	22	6.5	0.90	3.3
Lawrence	Mass	31	4.4	0.16	2.0
Winchester	Mass	28	4.5	0.17	2.3
Lansing	Mich	31	6.0	1.7	3.5
Minneapolis	Minn	31	5.6	0.80	2.3
Jackson	Miss	27	12	0.43	3.7
Pascagoula	Miss	21	8.9	1.0	3.8
Jefferson City	Mo	31	8.1	1.1	2.8
Helena	Mont	31	7.4	0.79	3.7
Lincoln	Nebr	21	5.5	0.96	2.7
Las Vegas	Nev	30	17	0.59	6.6
Concord	N. H	21	5.9	0.29	2.9
Trenton	N. J	31	4.6	1.1	2.7
Santa Fe	N. Mex	31	8.7	1.2	2.9
Albany	N. Y	30	5.1	0.34	2.8
Buffalo	N. Y	30	6.1	1.8	3.3
New York	N. Y	17	4.6	0.92	2.4
Gastonia	N. C	31	7.9	0.84	3.5
Bismark	N. Dak	31	8.6	0.71	3.2
Columbus	Ohio	30	6.5	0.99	2.8
Painesville	Ohio	30	5.5	1.2	3.0
Oklahoma City	Okla	31	5.1	0.76	1.9
Ponca City	Okla	29	3.2	0.12	1.1
Portland	Ore	31	3.0	0.64	1.6
Harrisburg	Pa	24	6.3	0.28	3.4
San Juan	P. R	15	2.5	0.84	1.5
Providence	R. I	31	5.9	0.18	2.5
Columbia	S. C	27	4.9	0.40	2.6
Pierre	S. Dak	30	40	0.85	4.0
Nashville	Tenn	30	9.1	1.1	3.4
Austin	Tex	29	4.2	0.68	1.6
El Paso	Tex	30	3.9	0.66	1.4
Salt Lake City	Utah	31	595	1.7	51
Barre	Vt	31	5.8	0.33	3.0
Richmond	Va	31	4.0	0.78	2.4
Seattle	Wash	30	2.2	0.47	0.95
Charleston	W. Va	29	4.6	1.2	2.6
Madison	Wis	31	5.1	1.2	3.0
Cheyenne	Wyo	29	378	1.3	21
Network average					3.4

* Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, JULY 1962

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
City	State		
Adak	Alaska	*	*
Anchorage	Alaska	610	6
Attu	Alaska	*	*
Fairbanks	Alaska	*	*
Juneau	Alaska	650	55
Kodiak	Alaska	*	*
Nome	Alaska	*	*
Point Barrow	Alaska	*	*
St. Paul Island	Alaska	*	*
Phoenix	Ariz	*	*
Little Rock	Ark	410	39
Berkeley	Calif	*	*
Los Angeles	Calif	*	*
Denver	Colo	*	*
Hartford	Conn	2,000	75
Dover	Del	*	*
Washington	D. C	2,500	85
Jacksonville	Fla	510	69
Miami	Fla	1,700	180
Atlanta	Ga	†<360	†<24
Agana	Guam	*	*
Honolulu	Hawaii	*	*
Boise	Idaho	*	*
Springfield	Ill	2,200	120
Indianapolis	Ind	790	160
Iowa City	Iowa	500	130
Topeka	Kans	1,200	83
Frankfort	Ky	700	48
New Orleans	La	990	90
Augusta	Maine	640	43
Presque Isle	Maine	560	91
Baltimore	Md	930	55
Rockville	Md	*	*
Lawrence	Mass	680	69
Winchester	Mass	710	31
Lansing	Mich	620	25
Minneapolis	Minn	2,100	280
Jackson	Miss	†<350	†<6.5
Pascagoula	Miss	550	110
Jefferson City	Mo	2,600	53
Helena	Mont	7,400	300
Lincoln	Nebr	2,200	240
Las Vegas	Nev	*	*
Concord	N. H	*	*
Trenton	N. J	1,400	3.3
Santa Fe	N. Mex	990	52
Albany	N. Y	660	15
Buffalo	N. Y	820	16
New York	N. Y	*	*
Gastonia	N. C	1,000	82
Bismarck	N. Dak	1,500	110
Columbus	Ohio	850	89
Painesville	Ohio	960	100
Oklahoma City	Okla	470	9
Ponca City	Okla	600	64
Portland	Ore	*	*
Harrisburg	Pa	1,400	18
San Juan	P. R	350	17
Providence	R. I	650	23
Columbia	S. C	610	81
Pierre	S. Dak	2,100	94
Nashville	Tenn	810	29
Austin	Tex	*	*
El Paso	Tex	980	57
Salt Lake City	Utah	6,700	140
Barre	Vt	1,000	130
Richmond	Va	460	59
Seattle	Wash	630	5
Charleston	W. Va	890	110
Madison	Wis	1,200	62
Cheyenne	Wyo	2,600	170

* No evaporated sample received.

† Placement of a "less than" sign (<) with an average concentration or total deposition value indicates that the sum of the "less than" *daily* values is 10 percent or more of the total, so that the true total or average is considered significantly less than the value shown.

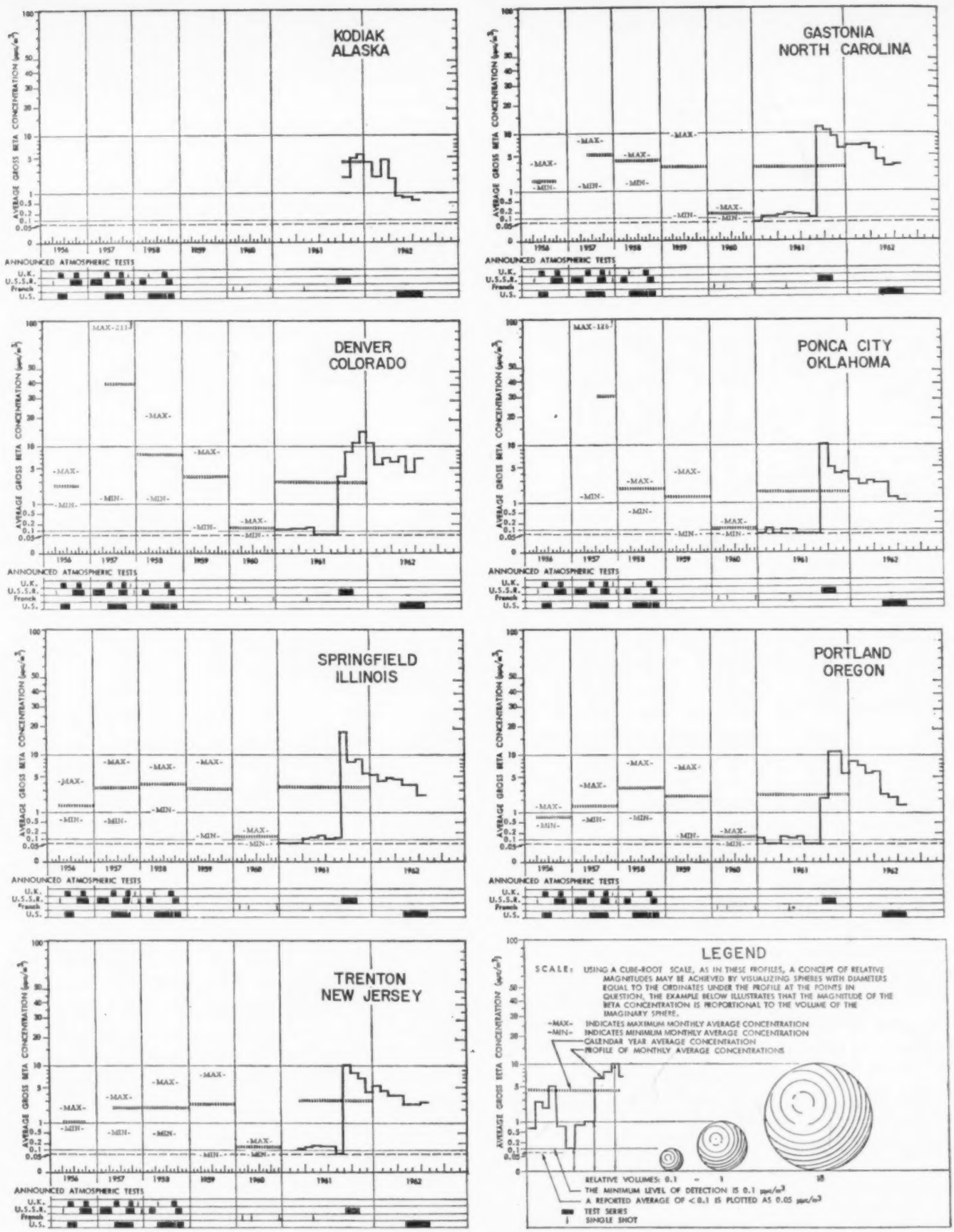


FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–JULY 1962

total deposition so that the true total or average is considered significantly less than the value shown.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through July 1962, are shown in figure 2.

THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM
June 1962

U.S. Naval Research Laboratory

Radioactivity measurements of surface air samples collected at various sites near the 80th Meridian (West) have been made since 1956. Sampling locations are shown in figure 3. This program is operated by the U.S. Naval Research Laboratory (NRL) with the cooperation of interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile, which collect the samples and forward them to NRL for analysis. Partial financial support of this program is provided by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

FIGURE 3.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

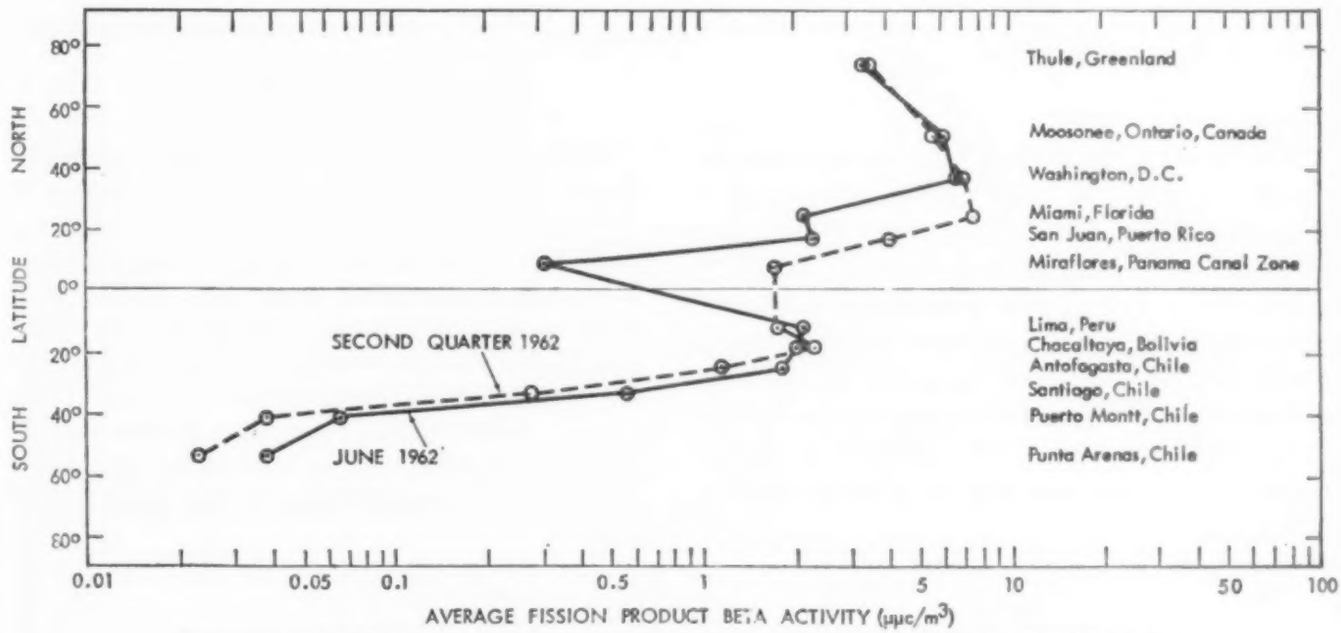


FIGURE 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENT OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), JUNE 1962

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL,[a] JUNE 1962

[Average concentrations in $\mu\mu c/m^3$]

Date	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, P. R.	Mauna Loa, Hawaii[c]	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1 2 3 4	0.018	0.021	0.159	1.68	4.22	2.90	[b]—	1.00	0.805	3.48	2.65	4.76	3.62	5.31
5 6 7 8 9 10 11	0.018	0.056	0.377	1.84	2.36	1.52	—	0.210	3.16	3.99	2.34	7.91	7.50	4.95
12 13 14 15 16 17 18	0.041	0.063	0.964	2.63	1.39	2.85	—	0.209	2.42	3.39	1.37	5.40	8.00	2.82
19 20 21 22 23 24 25	0.052	0.050	—	1.02	1.46	2.04	—	0.193	2.54	3.16	1.81	7.78	4.95	1.79
26 27 28 29 30	0.057	0.078	—	—	1.33	1.76	—	0.193	2.21	4.30	3.06	8.81	5.21	1.58
Weighted average	0.038	0.055	0.558	1.80	2.00	2.18	—	0.309	2.37	3.64	2.15	6.93	6.11	3.32

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period of that portion of the sampling period occurring in June 1962.

[b] Dash indicates samples were not received.

[c] Mauna Loa data has been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters) and about equally distant north and south of the equator.

The sampling procedure involves drawing air continuously for a 7-day period at a rate of approximately 1200 cubic meters per day through an 8-inch diameter, high efficiency filter, using a positive displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. Data are not extrapolated to time of collection.

The data in table 3 and the June profile in figure 4 show a conspicous low concentration at Miraflores compared to the adjacent stations. This was perhaps the result of two factors: (a) fresh radioactivity from U.S. Pacific tests went much further south while the Northern Hemisphere stations remained high because of the background of 1961 U.S.S.R. debris (plus perhaps some fallout from U.S. Pacific tests); and (b) the rainy season at Panama depressed the activity concentrations in the ground-level air.

NATIONAL AIR SAMPLING NETWORK
Second Quarter 1962

Division of Air Pollution, Public Health Service

The Public Health Service developed its National Air Sampling Network in 1953 to secure basic data on the nature and extent of air pollution throughout the United States and to detect trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

The current basic network consists of 110 sampling stations operating every year in 73 large cities and 37 nonurban areas. In addition to these every-year stations, 130 cities have stations which operate every other year. Thus, there are 240 sampling stations in all, of which about 175 are active in any given year.

The network stations are manned by cooperating Federal, State, and local agencies. Twenty-four hour samples of suspended particulate matter representing approximately 2000 cubic meters of air are collected on glass fiber filters on a bi-weekly random sampling schedule. The analyses of these samples include the measurement of total quantity of suspended particulate matter, the organic matter soluble in benzene, and gross beta radioactivity. Selected samples are analyzed also for nitrates, sulfates, and a number of metals.

Gross Beta Activity in Air

Gross beta activity data by states, for the years 1953 through 1958, were submitted by the Division of Radiological Health, Public Health Service, in testimony before the Joint Committee on Atomic Energy Hearing on Fallout from Nuclear Weapons Tests, Volume I, May 1959, pages 173-185. Subsequent data have been published quarterly in *Radiological Health Data* beginning with the October 1960 issue. Second quarter 1962 data are presented in table 4.

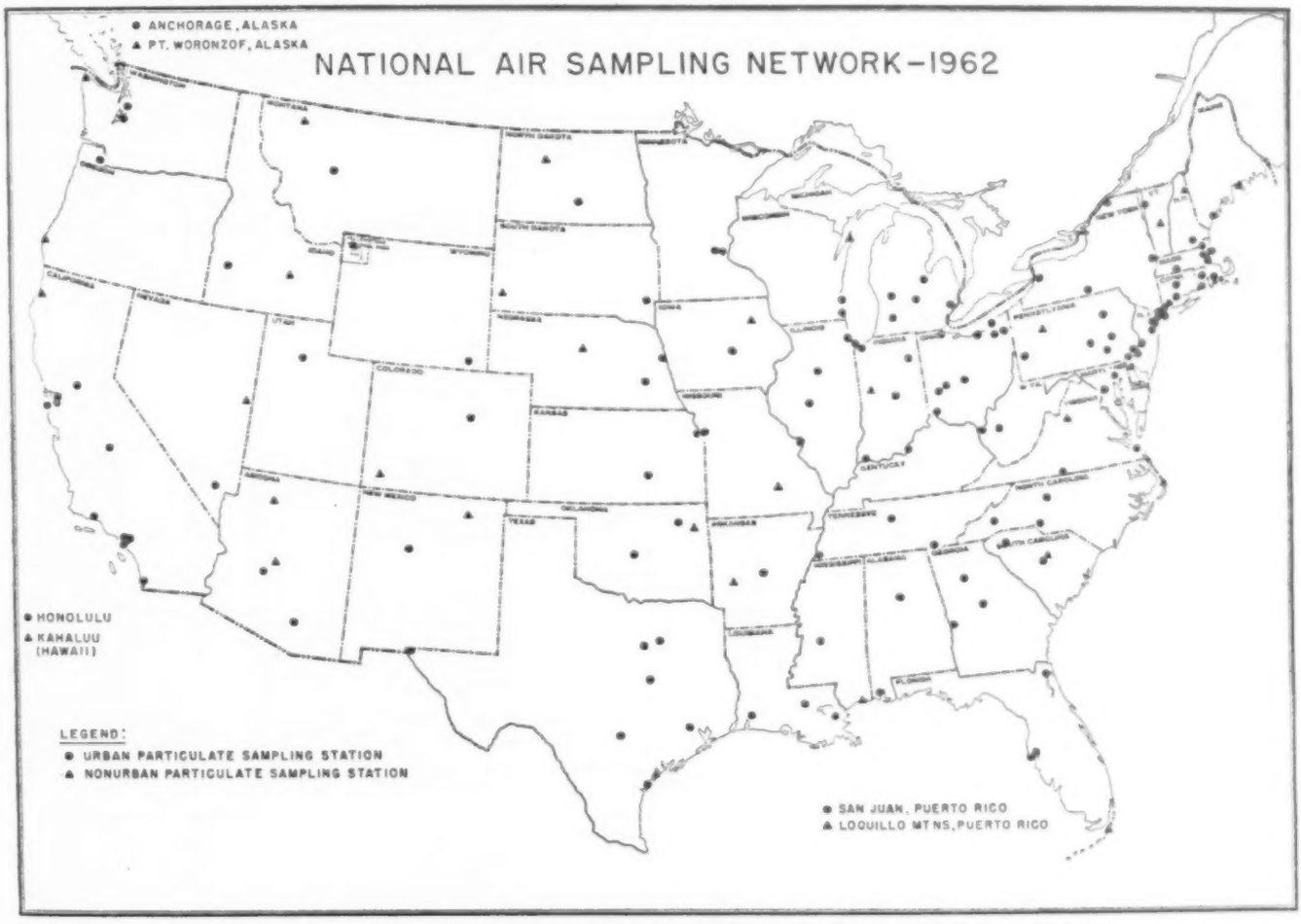


FIGURE 5.—NATIONAL AIR SAMPLING NETWORK STATIONS, 1962

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, SECOND QUARTER 1962

[Concentrations in pc/m³]

Station location		No. of samples	Minimum	Maximum	Average
Alabama:	Birmingham	6	4.1	15.7	9.7
	Mobile	6	2.2	14.6	7.9
Alaska:	Anchorage	7	1.4	6.6	3.7
	Pt. Woronzof *	7	0.5	4.9	2.6
Arizona:	Grand Canyon Pk *	6	6.1	17.0	11.9
	Maricopa Co *	6	6.3	33.8	15.2
	Phoenix	6	7.7	16.3	11.8
	Tucson	6	6.0	18.2	11.0
Arkansas:	Little Rock	6	2.5	12.9	8.7
	Montgomery Co *	5	3.2	12.5	7.5
California:	Burbank	7	2.5	20.2	8.5
	Fresno	6	3.4	15.1	7.9
	Humboldt Co *	6	0.8	3.5	1.9
	Los Angeles	7	1.7	20.1	6.5
	Oakland	5	0.7	14.5	5.4
	Pasadena	5	2.1	10.0	4.7
	Richmond	7	0.7	10.5	3.4
	Sacramento	6	2.3	18.6	7.0
	San Diego	7	2.3	12.3	6.5
	San Francisco	6	0.6	10.9	3.9
	Santa Barbara	6	1.4	16.7	4.8
Colorado:	Denver	6	4.4	7.3	5.5
	Montezuma Co*	5	5.0	15.0	8.6
Connecticut:	Bridgeport	6	3.6	8.9	6.3
	Hartford	6	2.9	7.0	5.5
	New Haven	6	2.2	11.8	7.3
	Stamford	6	2.1	11.7	5.6
Delaware:	Kent Co*	4	4.6	28.4	11.1
	Wilmington	7	1.9	8.0	5.0
District of Columbia:	Washington	6	3.3	8.2	6.3
Florida:	Florida Keys*	5	1.5	8.6	5.2
	Jacksonville	6	1.2	16.0	7.1
	St. Petersburg	7	1.9	13.0	7.1
	Tampa	6	1.0	12.8	7.5
Georgia:	Atlanta	6	3.1	11.1	6.1
	Columbus	6	2.8	18.0	7.3
	Macon	6	2.8	9.6	6.8
Hawaii:	Honolulu	6	2.0	4.6	3.1
	Kahaluu *	6	1.3	5.9	3.8
Idaho:	Boise Idaho	6	5.2	19.0	9.3
	Butte Co *	7	5.5	11.0	8.6
Illinois:	Chicago	7	3.2	10.3	6.5
	Cicero	6	2.1	7.0	5.2
	Peoria	6	5.4	10.7	7.9
	Springfield	6	3.5	16.3	8.9
Indiana:	East Chicago	5	1.6	11.2	4.9
	Evansville	6	3.3	6.2	4.8
	Fort Wayne	7	4.8	15.8	8.5
	Gary	6	4.9	12.8	7.4
	Indianapolis	6	4.0	11.6	7.4
	Montgomery Co *	6	3.6	11.4	7.5
Iowa:	Clayton Co *	6	2.6	16.1	7.5
	Des Moines	7	3.2	13.1	6.5
Kansas:	Kansas City	6	1.9	10.5	5.9
	Wichita	6	5.1	16.2	10.1
Kentucky:	Louisville	5	3.1	9.0	5.6
Louisiana:	Baton Rouge	7	2.2	14.4	9.6
	Lake Charles	6	0.6	10.3	6.3
	New Orleans	6	2.9	9.4	6.7
Maine:	Acadia Nat Pk *	4	3.2	8.9	5.4
	Portland	6	2.9	7.1	4.9
Maryland:	Baltimore	6	5.6	16.7	8.5
	Calvert Co *	6	5.3	11.6	8.0
Massachusetts:	Boston	7	1.3	11.5	6.4
	Fall River	7	3.2	15.5	9.7
	Lawrence	6	2.6	11.7	7.7
	Lynn	6	3.7	10.4	6.1
	Quincy	5	5.5	10.3	8.5
	Somerville	6	4.0	12.3	7.4
	Springfield	6	1.0	7.4	5.2
Michigan:	Detroit	7	4.3	7.1	5.4
	Grand Rapids	4	4.4	6.2	5.1
	Kalamazoo	6	4.1	17.2	7.8
	Lansing	6	2.7	7.2	5.1
	Saginaw	6	3.8	11.4	8.0
Minnesota:	Minneapolis	6	2.2	7.2	4.7
	St. Paul	5	3.4	6.7	5.3
Mississippi:	Jackson	5	2.9	9.5	6.9
	Jackson Co *	5	1.5	10.0	6.5
Missouri:	Kansas City	5	5.0	9.8	6.7
	Shannon Co *	6	5.0	13.6	9.7
	St. Louis	6	2.9	10.3	6.8
Montana:	Glacier Nat. Pk *	6	2.7	6.9	5.2
	Helena	6	6.0	12.0	8.7
Nebraska:	Lincoln	7	3.1	10.9	6.9
	Omaha	6	3.9	12.1	6.9
	Thomas Co *	7	5.1	16.3	8.0
Nevada:	Las Vegas	5	6.1	23.6	14.7
	White Pine Co *	6	6.4	13.8	9.2
New Hampshire:	Coos Co *	7	3.1	8.6	6.4
	Manchester	5	4.4	8.9	6.2
New Jersey:	Camden	6	1.8	9.2	6.0
	East Orange	6	0.6	8.7	5.6
	Elizabeth	7	1.4	10.9	5.7
	Newark	6	1.5	7.2	4.5
	Trenton	6	1.7	9.0	5.6
New Mexico:	Albuquerque	7	5.5	15.4	10.0
	Colfax Co *	6	6.0	17.0	10.1
New York:	Cape Vincent *	5	6.3	9.1	7.6
	Elmira	6	4.0	9.0	6.3
	Glen Cove	2	6.6	8.6	7.6
	Massena	6	1.2	8.2	4.4
	Mt. Vernon	5	6.2	15.7	9.2
	New Rochelle	6	1.9	8.7	5.6
	New York	7	2.9	10.2	7.6
	Rochester	6	1.0	9.2	5.8
	Troy	4	1.1	9.8	6.4
North Carolina:	Asheville	5	3.0	12.6	6.7
	Cape Hatteras *	6	6.0	14.1	9.5
	Charlotte	4	5.7	10.7	8.9
	Winston Salem	6	2.5	19.1	9.6
North Dakota:	Bismarck	6	1.9	11.0	5.4
	Ward Co *	6	2.2	7.2	5.1
Ohio:	Akron	7	2.6	12.5	6.6
	Cincinnati	5	2.1	14.8	7.0
	Cleveland	6	4.7	10.0	7.6
	Columbus	6	2.2	15.7	7.3
	Dayton	6	2.2	13.1	6.5
	Lorain	7	2.8	11.0	6.9
	Springfield	7	3.9	11.4	7.2
	Toledo	6	5.7	10.0	7.2
	Youngstown	7	4.6	10.3	7.6
Oklahoma:	Cherokee Co *	6	6.0	15.4	10.1
	Oklahoma City	7	7.6	13.4	10.1
	Tulsa	5	5.6	9.0	7.6
Oregon:	Curry Co *	6	0.5	4.7	2.0
	Portland	5	0.9	12.8	5.1
Pennsylvania:	Clarion Co *	5	4.6	16.1	7.6
	Harrisburg	5	0.7	10.0	6.6
	Lancaster	5	2.7	27.0	10.6
	Philadelphia	7	2.4	9.5	6.0
	Pittsburgh	6	1.9	11.4	6.7
	Reading	6	4.7	8.1	6.4
	Wilkes Barre	6	3.0	10.9	7.2
Puerto Rico:	Loquillo Mtns *	5	2.1	9.9	4.3
	San Juan	5	2.0	7.8	4.1
Rhode Island:	Providence	6	6.7	10.7	8.0
	Washington Co *	7	0.5	6.9	4.9
South Carolina:	Columbia	4	6.6	12.3	9.5
	Greenville	7	4.1	12.7	9.2
	Richland Co *	6	3.1	12.6	7.3

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, SECOND QUARTER 1962—Con.

[Concentrations in pc/m³]

Station location		No. of samples	Minimum	Maximum	Average
South Dakota:	Black Hills Frst *	6	4.2	11.2	6.6
	Sioux Falls	6	0.6	7.6	4.0
Tennessee:	Chattanooga	5	3.4	11.2	5.6
	Memphis	6	4.5	11.8	6.6
	Nashville	7	5.0	17.3	8.3
Texas:	Aransas Co *	5	1.6	13.1	5.9
	Corpus Christi	5	3.7	11.3	6.0
	Dallas	6	2.4	15.4	9.5
	El Paso	7	7.2	15.8	11.5
	Ft. Worth	6	3.4	8.2	5.0
	Houston	6	3.5	9.5	6.0
	San Antonio	4	1.8	7.2	4.0
	Waco	7	2.5	10.0	6.6
Utah:	Salt Lake City	7	5.3	15.9	10.3
Vermont:	Burlington	5	1.2	8.0	5.0
	Orange Co *	7	0.5	11.0	7.9
Virginia:	Danville	6	7.6	13.3	9.2
	Norfolk	5	5.2	10.9	7.1
	Shenandoah Nat. Pk *	7	2.3	10.8	6.1
Washington:	Clallam Co *	7	0.9	13.1	3.7
	Seattle	5	0.7	3.9	1.9
	Tacoma	5	0.6	5.2	3.0
West Virginia:	Charleston	7	2.7	9.4	6.3
	Huntington	5	4.4	10.0	6.1
Wisconsin:	Door Co *	3	4.0	7.1	5.5
	Milwaukee	4	2.6	7.2	5.2
	Racine	6	1.8	5.6	4.0
Wyoming:	Cheyenne	7	5.3	16.7	9.2
	Yellowstone Pk *	7	5.5	17.5	9.8

*Nonurban station

Gross Beta Activity In Precipitation

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. The collection stations are located at Weather Bureau offices or airport stations. Monthly composite samples of precipitation are collected at 29 stations and forwarded to the Network laboratory for analysis.

Samples are analyzed for total solids and a large number of metals and nonmetals. In addition, samples are analyzed for fission product gross beta radioactivity if a large enough volume remains after the requirements for the chemical analysis have been met. Second quarter 1962 data are presented in table 5.

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, NASN, SECOND QUARTER 1962

Station		April		May		June	
		pc/liter	nc/m²	pc/liter	nc/m²	pc/liter	nc/m²
Alabama	Montgomery	910	140	—	—	890	111
Florida	Tampa	*—	—	1030	66	439	32
Illinois	Chicago, (Midway)	—	—	1910	83	1170	65
Illinois	Chicago, (O'Hare)	—	—	2280	168	—	—
Louisiana	Lake Charles	—	—	—	—	504	66
Maine	Caribou	2010	85	1490	70	1180	60
Massachusetts	Nantucket	1190	107	—	—	474	43
Michigan	Sault Ste. Marie	1470	64	875	105	—	—
Minnesota	St. Cloud	—	—	1480	130	1830	115
Montana	Glasgow	—	—	1140	66	1160	76
Nebraska	Grand Island	—	—	1980	167	843	53
New York	Albany	1130	48	2010	95	—	—
North Carolina	Cape Hatteras	795	93	—	—	291	64
Ohio	Cincinnati (Airport)	—	—	1270	101	876	65
	Cincinnati (Gest St.)	—	—	1550	77	1010	87
Pennsylvania	Philadelphia	1300	97	2330	101	459	80
South Carolina	Charleston	2300	100	—	—	271	92
South Carolina	Greenville	1030	144	—	—	546	96
Tennessee	Nashville	785	114	—	—	643	107
Texas	Amarillo	—	—	—	—	1880	288
Texas	Brownsville	—	—	967	42	265	21
Texas	San Angelo	2460	148	—	—	—	—
Virginia (Wash. D.C.)	Sterling	2700	124	1750	76	521	45
Washington	Tatoosh	870	157	—	—	—	—

* Dash denotes no sample.

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
First Quarter 1962

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division, Department of National Health and Welfare, Dominion of Canada, conducts air and precipitation sampling programs. The 24 air and precipitation stations are located at airports, and the equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport.

Air

About 650 cubic meters of air are drawn through a high efficiency 4-inch diameter filter during a 24-hour period. Filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. A 2-inch diameter disk is removed from each filter and counted with a thin end-window Geiger flow counter system, cali-

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RFSP, FIRST QUARTER 1962

[Average concentration in $\mu\mu c/m^3$]

Station location	January	February	March	Station location	January	February	March
Calgary	8.9	7.6	9.0	Resolute	2.2	*—	9.6
Chatham	8.4	8.9	6.2	Saskatoon	7.9	6.3	6.0
Coral Harbour	6.0	5.6	5.2	Shearwater	10.3	8.9	6.2
Edmonton	9.7	7.8	6.4	Torbay	7.8	4.1	—
Ft. Churchill	4.8	5.1	5.6	Toronto	9.4	9.3	8.4
Ft. William	8.9	7.9	8.0	Vancouver	6.1	10.9	6.6
Fredericton	8.7	9.8	6.0	Whitehorse	6.5	9.4	7.9
Goose Bay	5.9	6.7	4.7	Windsor	9.3	8.8	9.5
Inuvik	8.0	7.8	6.2	Winnipeg	8.6	7.2	7.4
Kapuskasing	8.2	8.4	9.7	Yellowknife	7.3	6.2	6.9
Montreal	8.5	7.2	7.5	Maximum station ave	10.3	10.9	9.7
Moosonee	8.2	7.7	9.4	Minimum station ave	2.2	4.1	4.7
Ottawa	9.2	7.7	8.5	Overall average	7.8	7.6	7.3
Regina	8.7	6.7	6.9				

* Dash denotes no sample.

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, FIRST QUARTER 1962

Station location	January		February		March	
	Concentration ($\mu\mu c$/liter)	Deposition ($m\mu c/m^2$)	Concentration ($\mu\mu c$/liter)	Deposition ($m\mu c/m^2$)	Concentration ($\mu\mu c$/liter)	Deposition ($m\mu c/m^2$)
Calgary	1030	12.1	467	5.2	1460	15.2
Chatham	751	48.8	2040	48.8	751	55.0
Coral Harbour	[a] tr	14.5	tr	7.7	2430	21.0
Edmonton	1560	39.2	923	35.8	1340	34.1
Fredericton	739	47.1	812	56.3	2830	77.5
Ft. Churchill	70	12.5	1310	5.7	—	—
Ft. William	2240	33.0	885	50.7	2700	40.5
Goose Bay	328	16.2	391	19.7	874	64.7
Inuvik	675	20.9	873	21.9	918	11.0
Kapuskasing	458	18.3	272	7.9	1120	24.2
Montreal	3020	118.8	1490	114.4	1260	84.6
Moosonee	[b]—	—	—	—	806	28.0
Ottawa	1100	62.6	638	41.1	1080	50.6
Regina	2510	45.2	2420	31.3	1690	32.3
Resolute	tr	52.0	tr	96.7	tr	56.0
Saskatoon	2990	45.5	999	36.8	876	16.9
Shearwater	—	—	1090	171.5	1090	57.9
Torbay	505	53.1	648	140.0	1020	150.0
Toronto	1950	107.8	1520	113.3	2870	29.1
Vancouver	—	—	565	36.1	768	71.8
Whitehorse	927	24.7	2380	23.5	789	18.6
Windsor	1590	87.7	1690	133.1	1420	36.7
Winnipeg	1550	34.3	793	31.6	1380	41.6
Yellowknife	602	17.3	471	6.0	128	8.4
Average	1290	43.4	1080	53.7	1340	44.6

[a] tr denotes trace precipitation.
[b] Dash denotes no sample.

FIGURE 6.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

brated with a Sr^{90}–Y^{90} standard. The delay period between collection and counting is one week to avoid interference from naturally-occurring radon and thoron daughters. Air data for first quarter 1962 are presented in table 6.

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. First quarter precipitation data are presented in table 7.

More detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's annual reports for 1959 and 1960 (*1*, *2*).

REFERENCES

(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW (RP–3)*, (May 1960).
(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW (RP–4)*, (December 1961).

Previous coverage in *Radiological Health Data*:

Period	Issue
July 1959–June 1960	*January 1961*
Third quarter 1960	*April 1961*
Fourth quarter 1960	*August 1961*
First quarter 1961	*December 1961*
Second quarter 1961	*February 1962*
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*

Natural and Fission Product Radioactivity in Surface Air Particulates at Cincinnati, Ohio

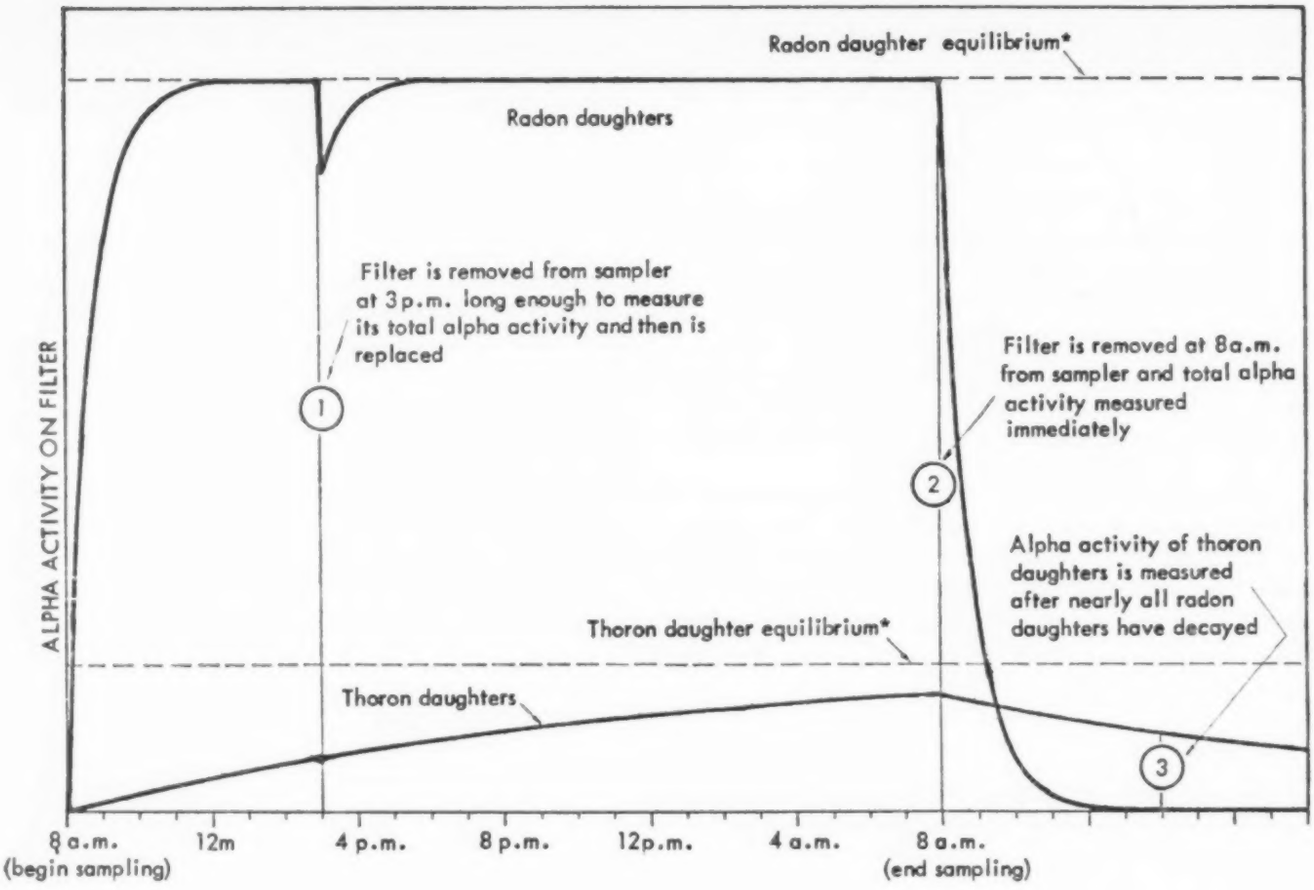
June 18–July 13, 1962

Division of Radiological Health, Public Health Service

The determination of natural radioactivity in the atmosphere is useful because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Some of the more important examples of naturally occurring and artificially produced airborne radioactivity are given in table 1. The physical state is of importance in the selection of sampling procedure.

TABLE 1.—EXAMPLES OF AIRBORNE RADIOACTIVITY

Physical state	Natural		Artificial
	Nuclides (radiation)	α half life	
Gaseous	Radon (α, γ) Thoron (α, γ)	3.8 days 54 seconds	Some fission products (β, γ)
Particulates	Radon daughters (α, β, γ) Thoron daughters (α, β, γ)	0.5 hours 10.6 hours	Most fission products (β, γ)



* Equilibrium values do not in fact remain constant throughout a 24-hour period but vary with changes of radon and thoron concentrations in air.

FIGURE 1.—IDEALIZED PROFILE OF ALPHA ACTIVITY ON FILTER DURING AND AFTER SAMPLING

Radon and Thoron

The earth's crust contains trace amounts of naturally-occurring uranium and thorium, each of which decays through a series of radionuclides, ending finally in stable isotopes of lead. One of the radionuclides in the uranium series is the inert gas, radon–222, commonly called "radon." In the thorium series, the inert gas decay product is radon–220, or "thoron." Some radon and thoron gases formed near the ground surface escape into the atmosphere before decaying to their particulate daughter products. Concentrations of radon and thoron in surface air depend on prevailing atmospheric conditions such as ambient temperature, wind, and pressure and on soil conditions such as moisture, porosity, and temperature that affect the rate of diffusion of the gases through the soil.

Most of the natural radioactivity in surface air is due to radon and its daughters. Thoron and its daughters contribute less because of thoron's shorter half life, and therefore, less time for diffusion through the pores of the soil to escape into the atmosphere. The natural radioactivity concentration in air shows a pronounced daily fluctuation. During a period of atmospheric inversion, such as often occurs in the early morning, radon and thoron tend to accumulate in the air near the ground surface. During periods of atmospheric turbulence, radon and thoron are dispersed in the atmosphere, leaving lower concentrations near the surface.

Measurement of radon and thoron concentrations in air may be accomplished by two general methods. The direct method involves the collection of radon and thoron gases by charcoal adsorption (*1*) while the indirect method utilizes the collection of airborne particulates,

TABLE 2.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS AT CINCINNATI, OHIO, JUNE 18–JULY 13, 1962

End of sampling period		Rn^{222} 8 a.m. ($\mu\mu c/m^3$)	Rn^{222} 3 p.m. ($\mu\mu c/m^3$)	Rn^{220} ($\mu\mu c/m^3$)	Beta activity ($\mu\mu c/m^3$)
June 18		880	160	3.0	9.53
19		240	150	1.8	6.89
20		460	140	4.8	7.21
21		620	130	6.8	5.55
22		440	200	5.4	8.65
25		700	160	4.2	5.63
26		770	160	6.7	9.10
27		410	240	4.7	7.80
28		240	110	9.6	7.16
29		610	140	6.5	7.93
July 2		600	190	6.7	7.48
3		260	200	2.9	5.72
5		480	200	3.3	1.91
6		500	190	3.5	1.41
9		250	70	3.5	2.98
10		690	120	5.4	3.24
11		670	160	6.7	5.21
12		250	130	3.1	4.87
13		500	170	5.4	4.94
Average		532	156	4.7	5.94
Range of counting errors (2σ)	Maximum	52	27	1.0	0.18
	Minimum	27	15	0.4	0.06

which include the radon and thoron daughter products, on the surface of a membrane filter. The choice of the indirect method for routine monitoring was made because of simplicity, sensitivity, and low cost.

The measurement of radon and thoron by the indirect method is based on the assumption that radon and thoron in the atmosphere are in equilibrium with their daughters. Under these conditions the particulate alpha activity (from the daughter products) retained on the membrane filter by a uniform flow of air may be theoretically related to the concentrations of radon and thoron in air. If radon and thoron activities in the air remain constant, the alpha activity on the filter while the sampler is in operation will reach 97 percent of equilibrium in 2.5 hours for radon daughters and in 53 hours for thoron daughters. The measurement of the activity by alpha scintillation, which is specific for alpha activity, eliminates interference from fission product beta activity.

The method used for the separate measurements of radon and thoron daughters is diagrammed in figure 1 where the history of one filter during a typical 24-hour sampling period and for a period following its removal is charted. At 3:00 p.m. the filter is removed momentarily from the sampler and counted. Although some thoron daughter activity is present, it is neglected and the activity is taken as radon daughter activity. The time of 3:00 p.m. was selected to represent the time of day most likely to have atmospheric turbulence and, therefore, lowest radon concentration in surface air. Radon and thoron concentrations often reach a maximum during an early morning atmospheric inversion condition. The 8:00 a.m. measurement of activity therefore approximates the daily maximum.

The measured alpha activities are adjusted to 100 percent equilibrium with factors based on length of sampling period and decay time after removal of filter. (*2*) The equilibrium alpha activities on the filter due to the respective daughter products may in turn be converted to radon and thoron concentrations in air by the following expressions:

$$\text{radon } (\mu\mu c/m^3) = 6\ A_r/F, \text{ and}$$

$$\text{thoron } (\mu\mu c/m^3) = 0.45\ A_t/F,$$

where A_r and A_t are the radon and thoron daughter alpha activities (dpm) respectively and F is the air sampling rate in liters per minute at the end of the sampling period.

Table 2 shows daily calculated radon activities for 8 a.m. and 3 p.m. and thoron for 8 a.m.

Fission Product Activity

The membrane filter used for the determination of radon and thoron is retained several days to allow for the decay of thoron daughters. At that time the beta activity is measured. This activity represents fission products and is reported in table 2.

REFERENCES

(*1*) Shleien, B.: The Simultaneous Determination of Atmospheric Radon by Filter Paper and Charcoal Adsorptive Techniques, Paper presented before 23rd Meeting of the American Industrial Hygiene Association and submitted for publication in the *American Industrial Hygiene Association Journal* on May 17, 1962.

(*2*) Setter, L. R., and G. I. Coats: The Determination of Airborne Radioactivity, *American Industrial Hygiene Association Journal, 22:* 64-9 (Feb. 1962).

SECTION II.—FOOD

Strontium–90 Concentrations in U.S. Wheat and Milling Products[1]

1960

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Concentrations of strontium–90 and calcium in U.S. wheat and milling products have been studied extensively at the Health and Safety Laboratory (HASL) since 1958. Table 2 compares the results of the survey of the 1960 crop with those previously published for the 1958 and 1959 crops. A pictorial representation of the data for 1959 and 1960 is presented in figure 1. Each cube, scaled to represent the concentration, is placed on the appropriate state. Material balances for the milling products are given in table 3, and new information on the 1960 milling products[2] is summarized in table 4. These data show a remarkable similarity in the relative distributions of strontium–90 among the different milling fractions. Moreover, this distribution pattern appears to have persisted over the three year period, in spite of the fact that fallout conditions varied considerably. The logical conclusion is that most of the strontium–90 found in wheat originated from a single source.

TABLE 1.—STRONTIUM-90 DEPOSITION IN WHEAT AND SOIL

Year	Wheat ($\mu\mu$c Sr^{90}/g Ca)	Soil Description	
		Cumulative (mμc Sr^{90}/m^2)	(mμc Sr^{90}/m^2) in June
1958	172*	18	0.58
1959	147*	26	0.57
1960	62	27	0.20

* Assuming 0.36 g Ca/kg of wheat.

Strontium–90 in wheat is derived either from the soil by root extraction or through direct deposition on foliar surfaces. Minimum estimates of strontium–90 in wheat from the latter source have been made by comparing the specific activity ($\mu\mu$c Sr^{90}/mg stable Sr) of flour with that of bran and assuming that the strontium–90 in the flour is derived solely from

[1] U.S. Atomic Energy Commission: *Summary Quarterly Reports, HASL–122*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1962), price $3.00.

[2] The production of flour from wheat grain is accomplished through milling. The first stage in this process involves the flattening and splitting of the kernels and the removal of the wheat *germ* which is not utilized in the production of flour. The grain is then passed through a series of rollers which remove successive layers of cells from the kernel. The highest grade flour is made mostly from the innermost part of the kernel and is called *patent flour*. Flour of lower quality is made from layers of cells nearer to the surface of the kernel, this flour is called the *first or second clear*. The outermost part of the wheat berry which forms a coat which is relatively easily removed is called the *bran*. Bran is not used in making flour. *Shorts* consists mainly of fine particles of bran mixed with some clear flour.

TABLE 2.—COMPARISON BETWEEN STRONTIUM-90 AND CALCIUM LEVELS IN UNITED STATES WHEAT SAMPLED IN 1958, 1959, AND 1960

State	Calcium (g/kg)			Strontium-90 (μμc/kg)			Strontium-90 (μμc/g Ca)		
	1958	1959	1960	1958	1959	1960	1958	1959	1960
California	[a]—	0.34	0.33	—	17	3.7	—	49 (2)[b]	11 (5)
Colorado	—	0.49	0.42	—	46	19	—	71 (5)	46 (2)
Idaho	—	0.34	0.35	—	5.7	6.1	—	17 (1)	18 (2)
Illinois	0.40	0.38	—	133	54		330 (1)	142 (1)	—
Iowa	—	0.54	0.38	—	62	34	—	109 (2)	89 (1)
Kansas	0.36	0.49	0.42	82	47	26	227 (1)	97 (1)	62 (1)
Michigan	0.36	0.38	—	42	48	—	118 (1)	125 (1)	—
Minnesota	0.35	0.33	—	51	59	—	162 (16)	181 (2)	—
Missouri	—	0.43	0.42	—	121	21	—	272 (4)	M 50 (1)
Montana	0.47	0.38	0.40	59	20	15	125 (1)	52 (1)	38 (1)
Nebraska	—	0.48	0.37	—	76	32	—	159 (3)	68 (3)
New York	0.36	0.37	0.41	44	44	16	121 (1)	119 (1)	40 (1)
North Dakota	0.31	0.33	0.29	40	51	26	134 (10)	154 (1)	91 (1)
Ohio	—	0.36	0.48	—	56	35	—	152 (11)	73 (4)
Oklahoma	0.41	0.40	0.39	34	63	35	82 (1)	159 (1)	90 (2)
South Dakota	0.35	—	—	61	—	—	171 (8)	—	—
Texas	0.44	0.51	—	44	51	—	99 (2)	99 (1)	—
Utah	—	0.48	0.44	—	21	7.9	—	45 (5)	19 (4)
Washington	—	0.32	0.35	—	9.2	7.0	—	30 (2)	20 (1)

[a] Dash indicates no sample.
[b] Numbers in parentheses indicate number of samples averaged.

the soil by root uptake (*1*). The inaccuracy of this assumption is apparent from the data presented in table 3. Despite the fact that the strontium–90 levels in soil probably increased in 1960 as compared to 1959, the strontium–90 concentration in patent flour decreased sharply. It follows that much of the strontium–90 in the patent flour was derived by translocation of strontium–90 directly deposited on the outer parts of the grain. This translocation effect should be more easily seen in 1962 by tracing fresh fallout expected to be found in wheat through Sr^{89}/Sr^{90} ratios in the milling fractions. Presumably this will be possible since it is expected that the 1962 wheat crop will be contaminated by fresh fallout from the Soviet test series that were held in late 1961.

The concentration of strontium–90 in wheat grown in the United States was estimated to be 62 ± 27 μμc/kg in 1958; 53 ± 19 μμc/kg in

TABLE 3.—STRONTIUM-90 MATERIAL BALANCE IN UNITED STATES WHEAT AND MILLING PRODUCTS

Material	Weight (kg)	[a]1958		[b]1959		[c]1960	
		μμc/kg	μμc in fraction	μμc/kg	μμc in fraction	μμc/kg	μμc in fraction
Input: Wheat	100	62	6200	53	5300	28	2800
Output: Patent Flour	58	12	696	9	522	4	232
1st & 2nd Clear	14	28	392	17	238	9	126
Germ & Shorts	17	133	2261	143	2431	66	1122
Bran	11	231	2541	163	1793	107	1177
Output total	100		5890		4984		2657
Difference			310 (5%)		316 (6%)		143 (5%)

[a] Production weighted average of 9 states.
[b] Production weighted average of 5 states representing 64 percent of 1958 production, *The World Almanac and Book of Facts for 1960.*
[c] Production weighted average of 6 states representing 55 percent of 1960 production, *The World Almanac and Book of Facts for 1962.*

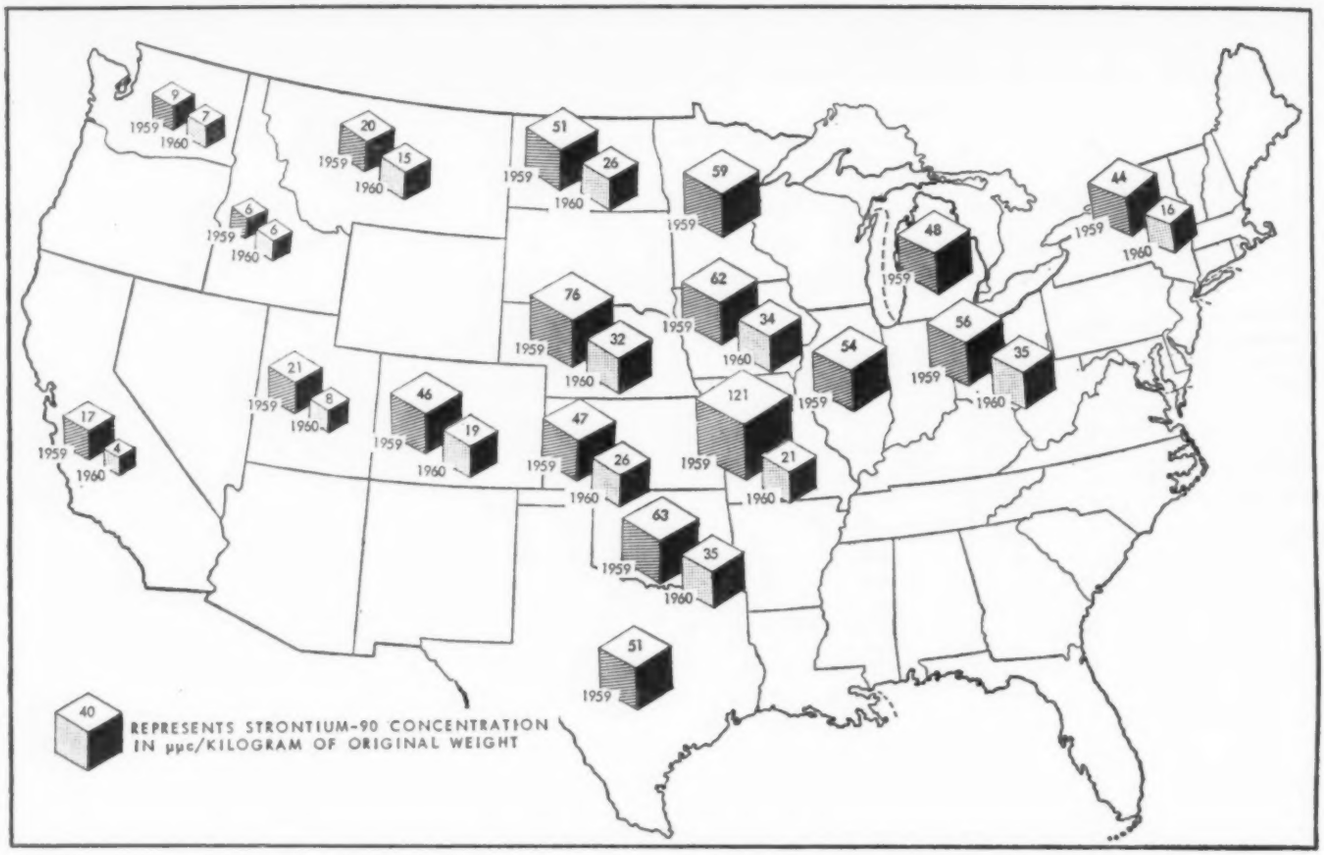

FIGURE 1.—STRONTIUM-90 IN U.S. WHEAT HARVESTED IN 1959 & 1960

TABLE 4.—STRONTIUM-90 AND CALCIUM IN WHEAT AND MILLING PRODUCTS 1960

State	Wheat	Bran	Germ	Shorts	Clear	Patent
μμc Sr^{90}/kg:						
Kansas	26	111	49	97	9.4	4.6
Montana	15	70	70	49	4.5	3.3
Nebraska	32	115	60	26	8.8	4.9
North Dakota	26	102	42	76	7.2	3.8
Ohio	31	95	37	56	12	5.4
Oklahoma—(80%), Texas—(20%)	44	138	61	110	11	3.8
μμc Sr^{90}/g Ca:						
Kansas	62	78	67	90	43	22
Montana	38	81	159	58	30	36
Nebraska	85	125	108	23	35	31
North Dakota	90	111	81	87	48	34
Ohio	78	68	61	80	46	36
Oklahoma—(80%), Texas—(20%)	113	141	95	119	38	20
g Ca/kg:						
Kansas	0.42	1.4	0.74	1.1	0.22	0.21
Montana	0.40	0.86	0.42	0.87	0.15	0.09
Nebraska	0.37	0.92	0.56	1.1	0.25	0.16
North Dakota	0.29	0.93	0.52	0.87	0.15	0.11
Ohio	0.41	1.4	0.61	0.70	0.26	0.15
Oklahoma—(80%), Texas—(20%)	0.39	0.97	0.63	0.94	0.29	0.19

1959; and 24 ± 9 μμc/kg in 1960.[3] While the difference between the 1958 and 1959 concentrations was not statistically significant, the difference between the 1959 and 1960 concentrations is significant. Since the level of strontium–90 in the soil increased between 1959 and 1960, the decline in the concentration of strontium–90 in wheat grown in 1960 must have been due to a decline in the fallout rate and a consequent decrease in direct deposition of strontium–90 on the grain.

Middleton has shown that wheat is most

[3] Weighted average of 14 states representing 73 percent of 1960 production. *The World Almanac and Book of Facts for 1962.* The error terms given for strontium–90 concentrations in U.S. wheat are one standard deviation from the production weighted average.

likely to be contaminated by direct deposition after the emergence of the ears from the boot (*2*). For the majority of wheat harvested in the United States, this occurs in June (*3*). The fallout rate in June for the midwestern wheat producing states can be estimated from the HASL monthly pot and funnel monitoring network. The cumulative deposit of strontium–90 in the soils of these states can also be estimated from the HASL-USDA soil sampling program. These estimates, together with the Sr^{90}/Ca ratio in wheat for 1958, 1959 and 1960, are shown in table 1.

From these data in table 1 we can find suitable values for proportionality factors "a" and "b" in an expression of the form,

$$V = a\,S + b\,R$$

where V is the Sr^{90}/Ca ratio in the wheat, S is the cumulative deposit of strontium–90 in the soil, and R is the fallout rate. A choice of "a" and "b" that fit the data reasonably well is, a = 0.12 μμc/g Ca/mc/mi² and b = 102 μμc/g Ca/mc/mi² deposited in June. Using these values for "a" and "b," the fraction of the Sr^{90}/Ca ratio in wheat due to direct deposition was about 90 percent for all three years. This result is in good agreement with the estimate of Menzel, et al. (*4*) for wheat grown in Maryland in 1959.

REFERENCES

(*1*) Agricultural Research Council Radiobiological Laboratory: *Strontium–90 in Human Diet in the United Kingdom–1958, ARCRL 1,* Her Majesty's Stationery Office, London (1959), p. 47.
(*2*) Middleton, L. J.: Radioactive Strontium and Cesium in the Edible Parts of Crop Plants after Foliar Contamination, *International Journal of Radiation Biology, 1:387* (October 1959).
(*3*) Private Communication, L. W. Briggle: U.S. Department of Agriculture, Beltsville, Maryland.
(*4*) Menzel, R. G., et al: Foliar Retention of Strontium–90 by Wheat, *Science, 134:*559-60 (August 25, 1961).

Previous coverage of wheat data in *Radiological Health Data*:

Period	Issue
1958–1959	*May 1960*
1958–1960	*October 1960*
1958–1959	*November 1960*
1958–1959	*April 1961*
1959 (foreign)	*April 1961*
1958–1959 (Canadian)	*July 1961*
1960	*January 1962*

Deposition of Strontium–90 in a 1960 Kansas Wheat Sample[1]

J. Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

Knowledge of the mechanism by which plants are contaminated by fallout is essential for the accurate prediction of future levels of strontium–90 in foods. A particularly important fact that must be known is whether plants become contaminated principally from strontium–90 that is absorbed from the soil or from strontium–90 that results from the direct deposition of fallout on the plant surfaces. The experiment presented here on the contamination of wheat may be of some help in resolving this problem.

A sample of wheat from Kansas harvested in 1960 was treated in such a way as to remove the epidermal layer of the bran coats. The resulting two fractions, together with an aliquot of the original wheat sample, were analyzed for strontium–90 and stable strontium. The results are presented in table 1.

If all of the strontium–90 in the wheat berry were derived from the soil, then the specific activity (μμc Sr^{90}/mg Sr) in each of the fractions of the berry would be the same. The outermost part of the berry, however, was exposed to direct deposition of strontium–90 from fallout in addition to that which was derived from the soil. If there had been no direct deposition of strontium–90 on the "beeswing," it would have had the same specific activity as the inner part of the berry, namely, 5.69 μμc Sr^{90}/mg Sr, and would have contained $5.69 \times 0.71 = 4.00$ μμc Sr^{90}. Since the observed amount of strontium–90 in this fraction was 7.1 μμc, the difference of 3.1 μμc could be attributed to direct deposition.

The strontium–90 in the stripped fraction of the wheat may not have originated entirely from strontium–90 in the soil as was assumed here, but rather some may have come from

[1] U.S. Atomic Energy Commission: *Summary Quarterly Report, HASL–127,* Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1962), price $3.00.

TABLE 1.—STRONTIUM IN WHEAT FRACTION

Wheat fraction	μμc Sr^{90}/kg	kg in fraction	μμc Sr^{90} in fraction	mg Sr/kg	mg Sr in fraction	Specific activity (μμc Sr^{90}/mg Sr)
Wheat	26.1	1.000	26.1	4.02	4.02	6.49
Stripped wheat	19.6	0.968	19.0	3.45	3.34	5.69
Beeswing *	216.4	0.033	7.1	21.57	0.71	10.00

* Fraction stripped from wheat.

strontium–90 that was directly deposited on the outer part of the berry and then translocated to the inner part. The estimate that 4.00 μμc Sr^{90} in the "beeswing" came from the soil is, therefore, a maximum estimate and 3.1 μμc must, therefore, be regarded as the minimum amount that was due to direct deposition.

There is considerable evidence to the effect that the amount of strontium–90 directly deposited on the wheat berry is proportional to the fallout rate (see page 392). One would expect, therefore, that the fraction of strontium–90 in wheat due to direct deposition would have been greater in a sample harvested in 1959 than one harvested in 1960 since the fallout was greater in 1959 than in 1960.

An experiment identical to the one described above was performed on a sample of Kansas wheat harvested in 1959 (*1*). The result was that an estimated 22 percent of the total strontium–90 in the wheat was the minimum amount that was ascribable to the direct deposition. The minimum amount of strontium–90 in the wheat due to direct deposition for the 1960 sample of 3.1 μμc was 12 percent of the total in the sample. These results substantiate the belief that direct deposition constitutes a very important factor in the contamination of wheat with strontium–90 from fallout.

REFERENCE

(*1*) Rivera, J.: Distribution of Strontium–90 in a 1959 Wheat Sample, *Science*, *133*:755–6 (March 17, 1961).

SECTION III.—MILK

Radionuclide Analyses of Pasteurized Milk

PASTEURIZED MILK MONITORING PROGRAM
June 1962

Division of Radiological Health
Division of Environmental Engineering and Food Protection
Public Health Service

Milk monitoring has been conducted by the Public Health Service since early 1957 when the first program was established to develop suitable sampling methods and radiochemical analytical procedures. Milk is produced every day throughout the year in practically every county of the United States. It can be readily checked in processing centers and is a good indicator of fallout in the diet. Raw milk was initially selected for investigation; however, it became evident that the milk actually consumed by the population should be included in a broader sampling program. The result was the initiation, in the first quarter of 1960, of a pasteurized milk sampling program designed to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in the pasteurized milk monitoring.

The June 1961 raw milk sampling results, reported in the November 1961 *Radiological Health Data* (*RHD*), represent the last regular publication of such data. A summary discussion of the raw milk sampling program in the December 1961 *RHD* presented the gross relationship between fallout and the occurrence of fission products in milk determined from this study.

During June 1962, the surveillance of pasteurized milk was conducted at 61 stations with the cooperation of State and local milk sanitation agencies who have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis (see figure 1). Publication in *RHD* follows about 3½ months after sample collection because of time required for shipment, processing, decay-product buildup, data compilation, and publication procedures.

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all states and additional points

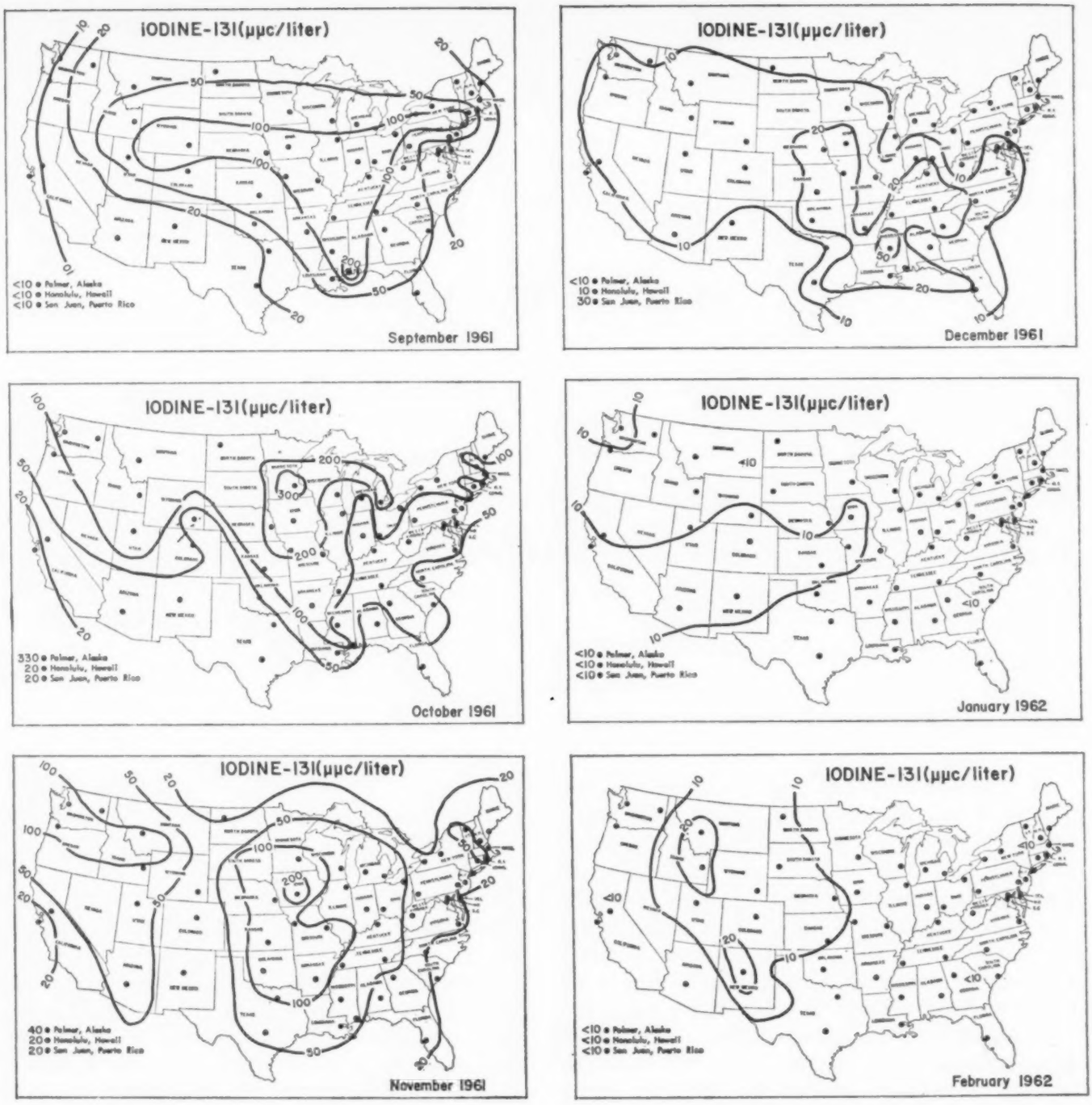

FIGURE 1.—IODINE-131 CONCENTRATION CONTOURS AND MILK SAMPLING STATIONS

when indicated by widely varying conditions of the milk supply or the need to cover large population groups. Each sample is composited in proportion to the volume of milk produced by those plants supplying not less than 90 percent of a city's milk supply. Prior to September 15, 1961, this composite sample was taken from one day's production of pasteurized milk per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling schedule has been increased in frequency. During June 1962, most stations were sampled twice a week. As all surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention and

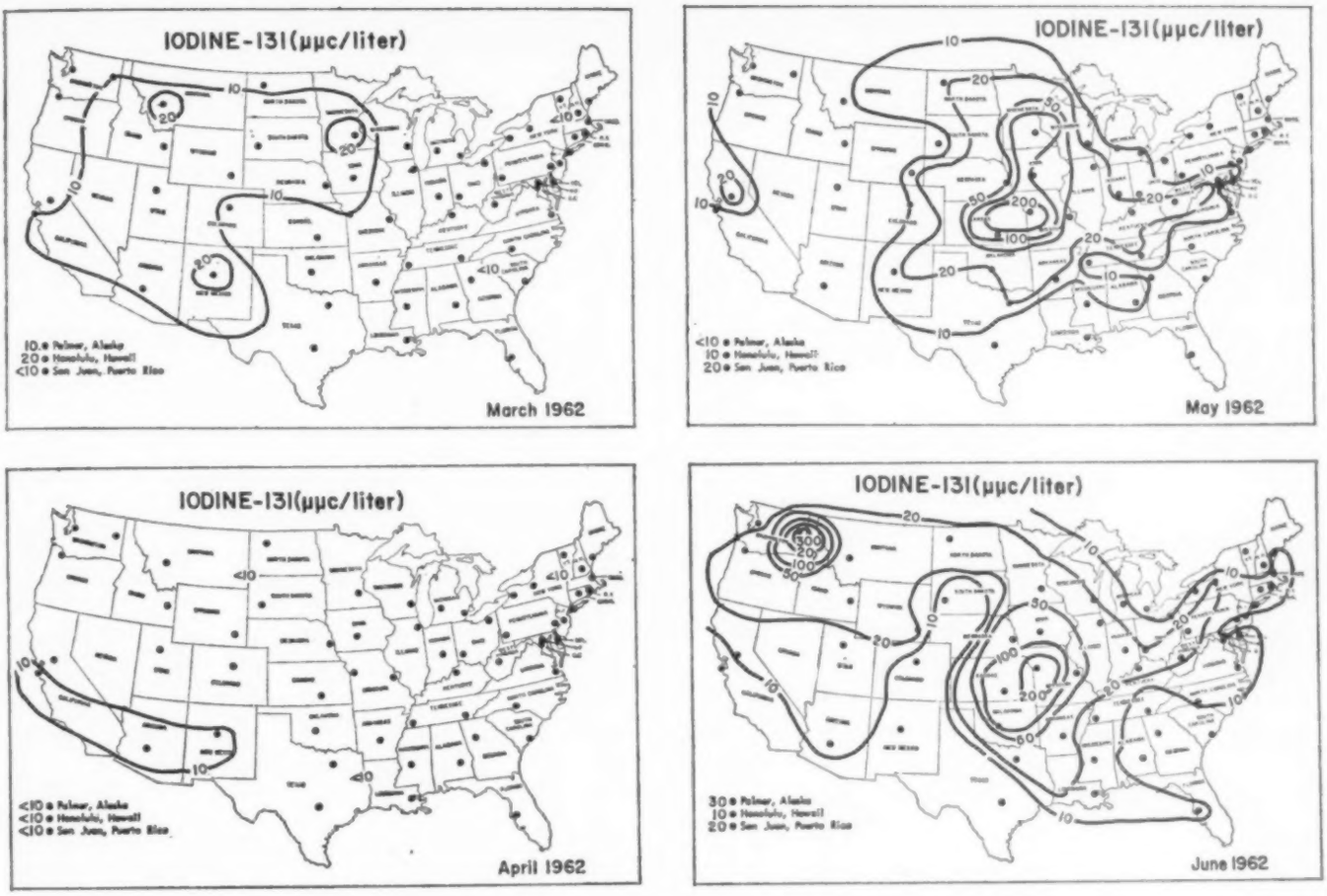

FIGURE 1.—IODINE–131 CONCENTRATION CONTOURS AND MILK SAMPLING STATIONS—Continued

adjustment in the pasteurized milk sampling program operation, further atmospheric nuclear testing may require an immediate re-evaluation and readjustment of the sampling frequency and analytical schedule for this program.

Iodine–131, cesium–137, and barium–140 are determined by gamma scintillation spectroscopy,[1] while strontium–89 and strontium–90 are determined following radiochemical separation. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for June 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Iodine–131 Geographical Distribution

Just prior to September 1961, the iodine–131 concentrations in pasteurized milk were not detectable. Figure 1 geographically displays the average iodine–131 concentrations in pasteurized milk from September 1961 through June 1962. These plots are based on concentrations in pasteurized milk representing milk sold in 61 cities distributed throughout the United States. Intervening milk sheds for smaller cities or the effect on intra- and interstate milk distribution are not taken into consideration. This permits the use of concentration contours for geographically presenting these data.

During the first few months of 1962, the iodine–131 concentrations in pasteurized milk were not generally detectable, since the iodine–131 present in November and December 1961 had decayed to relatively low levels. In May and June 1962, the concentrations in pasteurized milk again increased due to nuclear

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, JUNE 1962

[Average radioactivity concentrations in μμc/liter]

Sampling location		Calcium (gm/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Strontium-90 profile in *RHD*
State	City	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	Second quarter	Avg for month	
Alabama	Montgomery	1.20	1.21	105	55	19	16	10	<10	55	50	20	20	Oct. 62
Alaska	Palmer	1.08	1.05	35	60	9	13	10	30	20	25	<10	10	
Arizona	Phoenix	1.09	1.12	15	5	3	3	<10	10	10	10	<10	10	Sept. 62
Arkansas	Little Rock	1.17	1.18	225	120	37	32	20	20	95	80	40	30	July 62
California	Sacramento	1.09	1.12	30	20	5	5	10	10	15	10	<10	<10	Aug. 62
California	San Francisco	1.10	1.07	55	25	9	7	<10	<10	15	10	10	<10	Oct. 62
Colorado	Denver	1.16	1.19	30	60	8	13	<10	<10	10	30	<10	<10	Aug. 62
Connecticut	Hartford	1.19	1.24	15	35	11	14	<10	10	35	70	<10	<10	Aug. 62
Delaware	Wilmington	1.20	1.22	50	40	15	17	10	20	50	80	<10	<10	Sept. 62
District of Columbia	Washington	1.15	1.14	50	65	15	17	<10	10	40	65	10	20	Oct. 62
Florida	Tampa	1.21	1.21	25	25	10	11	<10	10	105	120	<10	10	Sept. 62
Georgia	Atlanta	1.20	1.18	120	70	22	20	<10	<10	80	75	20	20	Oct. 62
Hawaii	Honolulu	1.08	1.08	30	25	5	5	<10	10	25	30	<10	10	
Idaho	Idaho Falls	1.09	1.12	25	50	7	13	10	30	20	45	10	10	Sept. 62
Illinois	Chicago	1.16	1.19	35	70	11	15	20	30	30	65	10	10	Oct. 62
Indiana	Indianapolis	1.20	1.22	50	60	15	16	20	30	40	50	20	20	Aug. 62
Iowa	Des Moines	1.08	1.09	95	170	15	26	60	70	25	40	20	20	Sept. 62
Kansas	Wichita	1.08	1.08	65	80	12	16	120	130	20	40	20	20	July 62
Kentucky	Louisville	1.17	1.16	115	120	21	25	20	20	40	60	20	30	Sept. 62
Louisiana	New Orleans	1.23	1.24	215	145	37	38	<10	10	135	110	30	30	June 62
Maine	Portland	1.22	1.24	20	45	12	13	<10	10	50	95	<10	<10	Sept. 62
Maryland	Baltimore	1.17	1.15	45	60	15	17	10	<10	50	70	10	20	Sept. 62
Massachusetts	Boston	1.16	1.13	20	45	13	16	<10	10	50	100	<10	<10	Oct. 62
Michigan	Detroit	1.17	1.18	25	40	11	14	<10	<10	30	55	<10	<10	Aug. 62
Michigan	Grand Rapids	1.23	1.21	20	40	10	12	<10	10	30	55	<10	10	Sept. 62
Minnesota	Minneapolis	1.08	1.10	60	115	13	24	50	30	30	65	10	10	Oct. 62
Mississippi	Jackson	1.26	1.25	220	140	33	29	<10	10	85	85	30	30	Aug. 62
Missouri	Kansas City	1.09	1.11	130	215	18	25	150	240	30	50	40	50	Aug. 62
Missouri	St. Louis	1.08	1.12	85	115	16	23	30	60	30	50	10	20	June 62
Montana	Helena	1.08	1.09	45	75	10	16	20	30	25	50	10	10	July 62
Nebraska	Omaha	1.14	1.09	70	130	13	24	40	60	20	40	10	20	Sept. 62
New Hampshire	Manchester	1.15	1.06	15	35	10	12	<10	<10	60	115	<10	<10	Sept. 62
New Jersey	Trenton	1.13	1.09	25	35	10	12	<10	<10	30	60	<10	<10	Aug. 62
New Mexico	Albuquerque	1.09	1.10	15	20	4	6	10	<10	<5	<5	10	<10	July 62
New York	Buffalo	1.16	1.12	20	40	10	13	<10	10	40	80	<10	<10	Aug. 62
New York	New York	1.13	1.14	20	40	12	14	10	10	40	85	<10	<10	Oct. 62
New York	Syracuse	1.17	1.21	20	30	10	12	20	20	25	50	<10	<10	July 62
North Carolina	Charlotte	1.22	1.23	95	90	22	27	<10	10	55	70	20	20	July 62
North Dakota	Minot	1.10	1.09	60	120	16	30	20	20	30	70	<10	<10	Sept. 62
Ohio	Cincinnati	1.18	1.21	65	70	17	19	20	20	30	50	20	20	Aug. 62
Ohio	Cleveland	1.15	1.15	35	60	11	14	<10	10	30	65	<10	<10	July 62
Oklahoma	Oklahoma City	1.15	1.14	115	135	21	29	60	160	60	95	30	50	Oct. 62
Oregon	Portland	1.13	1.14	95	65	17	14	10	30	55	65	10	<10	Aug. 62
Pennsylvania	Philadelphia	1.16	1.17	35	40	13	13	<10	10	45	75	<10	<10	July 62
Pennsylvania	Pittsburgh	1.17	1.18	35	55	14	17	10	30	45	90	<10	<10	June 62
Puerto Rico	San Juan	1.13	1.15	75	55	11	13	20	20	55	50	20	20	
Rhode Island	Providence	1.19	1.23	20	35	12	13	10	10	45	85	<10	<10	Sept. 62
South Carolina	Charleston	1.20	1.19	95	60	21	20	<10	<10	75	80	20	20	Aug. 62
South Dakota	Rapid City	1.09	1.19	70	185	17	40	<10	<10	30	85	10	<10	Oct. 62
Tennessee	Chattanooga	1.24	1.22	200	105	28	24	10	<10	90	70	30	20	Oct. 62
Tennessee	Memphis	1.21	1.20	160	115	27	26	<10	10	40	45	30	20	Sept. 62
Texas	Austin	1.17	1.14	35	30	8	8	<10	<10	25	40	<10	10	Oct. 62
Texas	Dallas	1.18	1.19	115	85	18	18	20	30	50	50	20	30	Aug. 62
Utah	Salt Lake City	1.11	1.12	25	40	8	14	<10	10	30	75	<10	10	June 62
Vermont	Burlington	1.13	1.10	15	30	10	13	<10	<10	30	55	<10	<10	Aug. 62
Virginia	Norfolk	1.19	1.19	70	70	17	21	<10	10	55	80	10	20	Aug. 62
Washington	Seattle	1.12	1.15	80	65	18	19	<10	10	55	75	<10	<10	Oct. 62
Washington	Spokane	1.13	1.16	55	85	14	18	120	350	35	55	<10	<10	Aug. 62
West Virginia	Charleston	1.17	1.14	80	115	18	23	20	20	35	60	20	30	Oct. 62
Wisconsin	Milwaukee	1.20	1.18	15	35	8	11	10	20	15	25	<10	<10	Sept. 62
Wyoming	Laramie	1.09	1.13	35	60	8	15	20	20	25	50	10	10	Sept. 62
Network average		1.15	1.16	65	71	14	17	20	30	40	61	10	14	

weapons testing. The highest June average iodine–131 concentration in pasteurized milk appeared at Spokane, Washington.

Strontium–90 Profiles

In previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from selected cities in the monitoring program were published. An additional 14 cities are presented in figure 2. Each graph shows the strontium–90 concentrations in milk from selected cities in 4 geographic regions of the United States. The usual

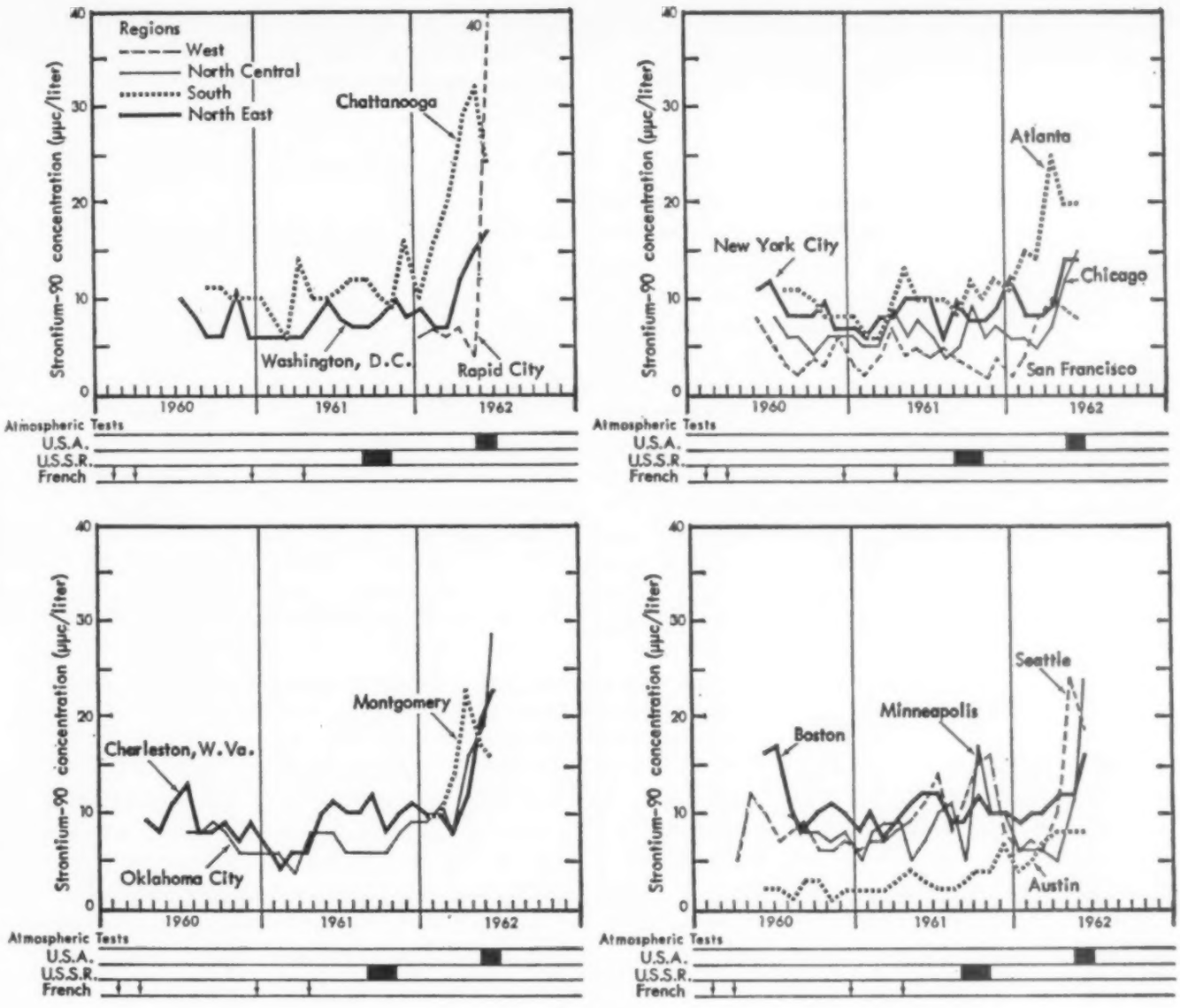

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

regional differences (higher strontium–90 in the East than in the West) are not evident in the selected profiles. The North Central region has shown the greatest change. Strontium–90 concentrations in milk produced in this region are now similar to those prevalent in the South.

Radionuclides in Raw Milk from the Vicinity in the Nevada Test Site

July 1961–June 1962

U.S. Atomic Energy Commission

Shortly after the Operation Plumbob test series in 1957, the Atomic Energy Commission Off-Site Organization at the Nevada Test Site contracted with the Public Health Service's Robert A. Taft Sanitary Engineering Center for analyses of radionuclides in raw milk (Las Vegas milk is pasteurized) produced in the vicinity of the Nevada Test Site. In April 1960, the Southwestern Radiological Health Laboratory of the Public Health Service Division of Radiological Health assumed responsibility for the radionuclide analyses of milk samples obtained in the off-site monitoring program (see sampling locations on figure 1). All milk sample analyses taken in the vicinity of the

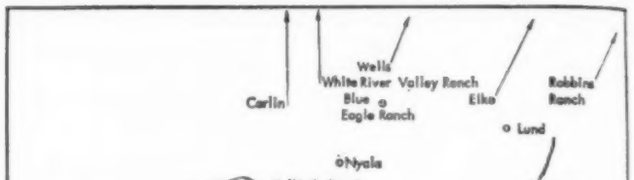

FIGURE 1.—MILK SAMPLING LOCATIONS AT THE NEVADA TEST SITE

TABLE 1.—RADIONUCLIDE CONCENTRATIONS IN MILK SAMPLES FROM THE VICINITY OF NEVADA TEST SITE

[Radioactivity concentrations in $\mu\mu c$/liter]

Collection date	Location	Calcium (g/liter)	Strontium–89	Strontium–90	Iodine–131	Cesium–137	Barium–140 lanthanum–140
July 20, 1961	Las Vegas	0.94	<5	2	<10	<10	<20
Aug. 21, 1961	Las Vegas	0.86	<5	2	<10	<10	<20
Aug. 15, 1961	Alamo	0.86	<5	2	<10	<10	<20
Sept. 6, 1961	Springdale	[a]—	[a]—	[a]—	<10	<10	570
Oct. 31, 1961	Hiko	1.08	95	4	720	20	60
Oct. 31, 1961	Las Vegas	1.10	15	3	40	<10	<20
Nov. 1, 1961	Glendale	1.06	<5	2	60	<10	<20
Nov. 2, 1961	Caliente	1.20	<5	4	80	<10	20
Nov. 29, 1961	Fallini's Ranch	1.33	40	6	90	50	70
Dec. 1, 1961	Las Vegas	1.02	15	2	40	25	60
Dec. 1, 1961	Diablo	1.16	5	3	30	15	<20
Dec. 13, 1961	Alamo	1.07	10	2	<10	<10	<20
Dec. 13, 1961	Hiko	1.10	<5	2	<10	<10	<20
Dec. 18, 1961	Las Vegas	1.07	<5	4	<10	<10	<20
Dec. 21, 1961	Las Vegas	1.12	5	3	<10	<10	<20
Jan. 3, 1962	Panaca	1.10	<5	2	<10	<10	<20
Feb. 13, 1962	Las Vegas	1.00	<5	2	<10	10	<20
Feb. 22, 1962	Alamo	1.00	<5	2	<10	<10	<20
Feb. 26, 1962	Springdale	1.00	30	3	<10	30	<20
Apr. 4, 1962	Caliente	1.10	5	3	<10	<10	<20
Apr. 18, 1962	Fallini's Ranch	1.18	10	5	<10	10	<20
Apr. 19, 1962	Alamo	1.15	<5	3	<10	<10	<20
Apr. 19, 1962	Panaca	1.14	5	4	<10	10	<20
Apr. 25, 1962	Lund	1.08	<5	4	<10	<10	<20
Apr. 26, 1962	Springdale	1.08	25	4	20	25	<20
May 9, 1962	Lund	1.08	<5	1	<10	<10	<20
May 17, 1962	Hiko	1.14	5	1	<10	<10	<20
June 5, 1962	Searles Ranch	[b]—	[b]—	[b]—	<10	20	<20
June 5, 1962	Las Vegas	[b]—	[b]—	[b]—	<10	30	<20
June 5, 1962	Caliente	[b]—	[b]—	[b]—	<10	25	<20
June 5, 1962	Alamo	[b]—	[b]—	[b]—	<10	35	<20
June 7, 1962	Springdale	[b]—	[b]—	[b]—	<10	50	<20
June 4, 1962	Panaca	[b]—	[b]—	[b]—	<10	<10	<20
June 8, 1962	Fallini's Ranch	[b]—	[b]—	[b]—	<10	70	<20
June 13, 1962	White River Valley Ranch	[b]—	[b]—	[b]—	40	80	<20
June 18, 1962	Blue Eagle Ranch	[b]—	[b]—	[b]—	20	180	<20
June 20, 1962	Adavan	[b]—	[b]—	[b]—	360	75	<20
June 21, 1962	Elko	[b]—	[b]—	[b]—	610	200	<20
June 22, 1962	Robbins Ranch	[b]—	[b]—	[b]—	520	140	<20
June 22, 1962	Carlin	[b]—	[b]—	[b]—	160	120	<20
June 23, 1962	Wells	[b]—	[b]—	[b]—	80	110	<20

[a] Sample not valid.
[b] Not available in time for inclusion.

Nevada Test Site since July 20, 1961, are reported in table 1. Gross beta concentrations determined by this monitoring program in water supplies in off-site areas of the Nevada Test Site have been published previously in *Radiological Health Data.*

Strontium–90 in Canadian Dried Milk Products

RADIOACTIVE FALLOUT STUDY PROGRAM
First Quarter 1962

Department of National Health and Welfare, Ottawa, Canada

Beginning November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium–90 concentrations were initiated by the Department of National Health and Welfare. Through the cooperation of the Marketing Division of the Canadian Department of Agriculture, four 1-pound samples of dried milk from each station were collected by dairy products inspectors each month for the Radioactive Fallout Study Program. No precise control is maintained over the method of sample collection, since whether or not all samples are collected on the same day or if the sample is truly representative of the milk produced in a given area is not known.

Because of uncertainties introduced by the method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. It is possible, however, to consider all the results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figure 2. It should be emphasized that average concentrations over a considerable period of time are more meaningful from the public health point of view than fluctuating monthly concentrations.

A detailed discussion of the sampling and radiochemical methodology employed may be found in the Department's publication (*1*).

Table 1 presents the results of measurements of strontium–90 in Canadian dried milk powder for the first quarter of 1962, which were taken from the "Quarterly Report of the Radioactive Fallout Monitoring Program," dated July 1961,

TABLE 1.—STRONTIUM-90 IN CANADIAN DRIED MILK POWDER, 1962

[Concentrations in $\mu\mu c/g$ Ca]

Station	Type of milk	January	February	March
Calgary	Skim milk	4.8	4.6	5.0
Edmonton	Skim milk	6.6	7.3	5.3
Granby region:				
Lawrenceville	Skim milk	14.0	15.4	14.9
Nicolet	Skim milk	6.0	7.5	8.3
Halifax	Skim milk	7.7	7.0	9.0
La Durantye	Skim milk	11.5	11.2	N.S.
London	Skim milk	3.4	3.3	4.6
Megantic	Skim milk	13.0	10.3	8.8
Moncton	Buttermilk	7.5	6.7	7.7
Ottawa	Skim milk	4.7	5.1	6.1
Saskatoon	Buttermilk	4.7	4.5	6.9
Sussex	Skim milk	8.2	9.4	9.1
Vancouver	Skim milk	7.7	7.0	6.7
Walkerton	Skim milk	4.6	4.4	3.2
Winnipeg region:				
Arborg	Buttermilk	4.8	4.8	4.3
Grunthal	Buttermilk	4.6	4.5	4.0
Average		7.1	7.1	6.9
12-month average (April 1961–March 1962)				0.8

FIGURE 1.—CANADIAN DRIED MILK SAMPLING STATIONS

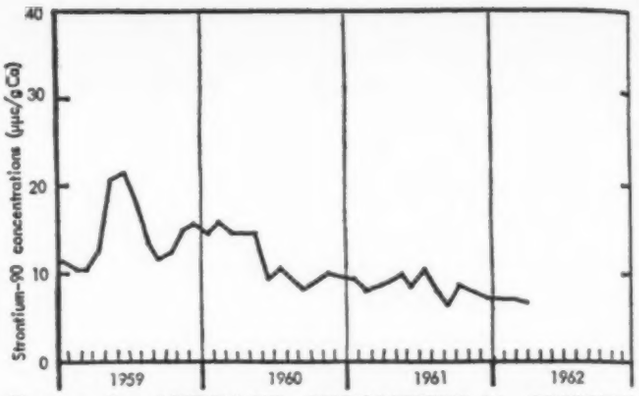

FIGURE 2.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK PRODUCTS

published by the Radiation Protection Division of the Department of National Health and Welfare.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g Ca to other milk data in units of μμc/liter, it can be assumed that Canadian powdered milk has approximately 1.2 g Ca/liter of liquid milk. Thus, Canadian powdered milk data may be compared to liquid milk by multiplying the former values by 0.8.

Previous coverage in *Radiological Health Data*:

Period	Issue
January 1956–March 1960	*September 1960*
Second quarter 1960	*December 1960*
Third quarter 1960	*April 1961*
Fourth quarter 1960	*August 1961*
First quarter 1961	*December 1961*
Second quarter 1961	*February 1962*
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*

REFERENCE

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, *CNHW (RP–1)*, (July 1958).

Iodine–131 and Strontium–90 in Milk from the United Kingdom[1, 2]

January 1961–April 1962

Agricultural Research Council Radiobiological Laboratory, England

Since 1958, the Agricultural Research Council Radiobiological Laboratory has performed strontium–90 analyses of raw milk produced in the United Kingdom. For the "country-wide" survey, raw milk samples are obtained every two weeks from over 200 depots selected according to a statistical plan, which handle more than 40 percent of the country's total milk production. The milk samples from the depots are composited to represent each zone as shown in figure 1.

Iodine–131

When it became apparent in September 1961 that the resumption of nuclear weapons testing was likely to lead to an appreciable contamination of milk, arrangements were made to receive milk daily because considerable day to day variations can occur in the iodine–131 concentrations in milk. Thus, during the period when the highest levels occurred (October and November, 1961) samples were obtained daily from up to 23 "regular sampling points" of which at least two were in each of the zones listed in table 1. In addition, country-wide sampling was also carried out once each week to provide fuller information on regional differences. When the levels decreased in early December 1961, the number of regular sampling

[1] Agricultural Research Council Radiobiological Laboratory: *Interim Report on Radioactivity in Milk, ARCRL–6*, Her Majesty's Stationery Office, London (December 1961), price 2 s.Od.

[2] Agricultural Research Council Radiobiological Laboratory: *Interim Report on Radioactivity in Diet, ARCRL–7*, Her Majesty's Stationery Office, London (May 1962), price 2 s.Od.

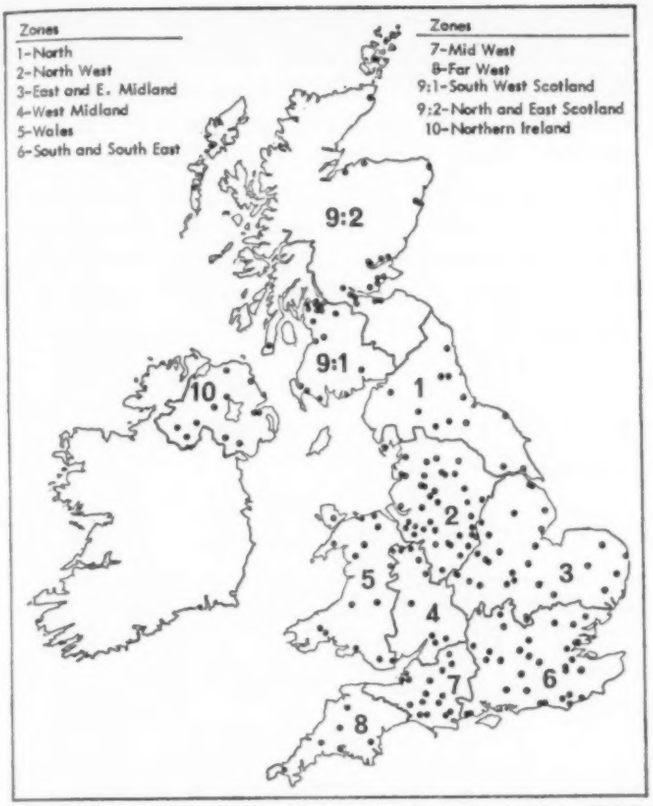

FIGURE 1.—MILK SAMPLING LOCATIONS FOR COUNTRY-WIDE SURVEY

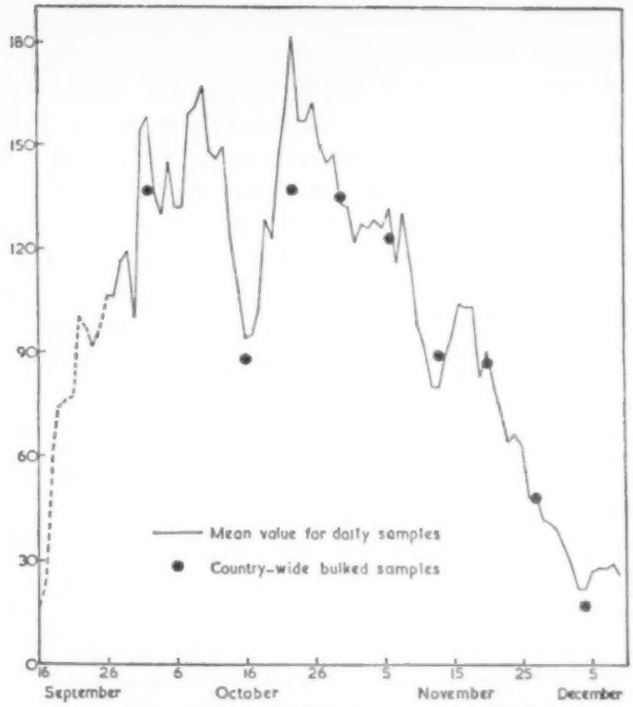

FIGURE 2.—IODINE–131 IN UNITED KINGDOM MILK

points was reduced to 7 and later to 6, distributed throughout the country. The frequency of the collections from the country-wide survey was reduced to once every 2 weeks. By the end of December the amount of iodine–131 in milk was below the limit of accurate detection in all samples, therefore the number of analyses was further reduced by bulking milk collected from wider areas.

The iodine–131 concentrations were determined by gamma counting after a rapid concentration process. Formalin is added to the milk and the proteins precipitated by the addition of trichloracetic acid; silver halide is subsequently precipitated. The gamma activity of the combined precipitate of protein and silver chloride is then counted using a 4" by 3" sodium iodide (thallium activated) crystal; the content of iodine–131 is calculated from the count-rate in the 364 kev photopeak.

The iodine–131 results from the country-wide survey and the regular sampling points have been combined in table 1. Because of the magnitude of day to day variations (see figure 2) the results of the country-wide survey do not by themselves provide a precise estimate of the average level since sampling was commenced. Some samples were collected on days when the results for the regular sampling points show that the content of milk was either appreciably higher or lower than the weekly average. A better estimate of the weekly mean levels throughout the country can be obtained by combining the results for the regular sampling sites with those for the country-wide survey. This was done by applying a correction factor to the country-wide samples consisting of the ratio of the mean value for the regular sampling points on the same day the country-wide sample was taken to the mean value for those points during each week. This calculation was made separately for each zone. For the 10 zones listed in table 1 the mean concentration for the 32 weeks ending April 28, 1962, ranged from 23 to 51 pc/liter, with a country-wide average level of 36 pc/liter.

Strontium–90

Whereas iodine–131 can be measured in milk within a few hours of the receipt of samples, measurements of strontium–90 take a considerably longer period. Not only is elaborate chemical separation necessary but also the strontium–90 can be adequately determined only by studying the decay of its radioactive

daughter, yttrium–90, over a period of several weeks. Therefore, the reporting of strontium–90 analyses lags that for iodine–131 by at least 2 months. January through December 1961 strontium–90 analyses are reported in table 2.

During 1961 the collection of milk for the country-wide survey of strontium–90 contamination was continued on the basis described previously. On account of the marked reduction in the concentrations of strontium–90 in milk during 1960 it was considered justified to reduce the analytical effort given to this work. The milk from 5 zones in England which had previously been assayed separately every 3 months was combined for analysis; after weapons testing was resumed in September 1961, the milk from each zone was again examined separately. In May 1961, the temporary division of Scotland into two zones was abandoned.

TABLE 1.—IODINE-131 CONCENTRATIONS IN MILK THROUGHOUT THE UNITED KINGDOM, 1961–1962

[Average concentrations in pc/liter]

Zone (See figure 1)	September		October				November				December				Apr	Average Sept–Apr
	16–23	24–30	1–7	8–14	15–21	22–28	29–4	5–11	12–18	19–25	26–2	3–9	10–16	17–24	25–28	16–28
1. Northern England	76	97	123	115	87	117	119	88	100	75	27	<15	<15	<15	<15	32
2. Northwest England	57	73	93	131	99	109	115	102	97	73	43	18	<15	<15	<15	32
3. East & East Midlands	52	66	84	78	59	100	81	56	59	66	44	<15	<15	<15	<15	23
4. West Midlands	67	86	108	130	98	111	119	121	118	76	31	31	41	23	<15	36
5. Wales	89	114	145	234	177	201	194	159	155	87	50	24	<15	<15	<15	51
6. South & Southeast England	83	107	136	88	67	84	125	57	84	65	50	24	<15	<15	<15	30
7. Midwestern England	56	72	91	114	86	108	141	124	102	89	50	21	<15	<15	<15	33
8. Farwestern England	52	67	85	187	142	205	175	143	138	79	43	37	37	21	<15	44
9. Scotland	139	179	227	208	157	143	104	93	84	30	18	18	<15	<15	<15	44
10. Northern Ireland	132	169	214	152	115	156	163	200	129	77	32	21	34	19	<15	50
Production weighted mean	77	99	125	141	106	127	130	108	103	71	40	20	<15	<15	<15	36

TABLE 2.—STRONTIUM-90 CONCENTRATIONS IN MILK THROUGHOUT THE UNITED KINGDOM, 1961

[Average concentrations in pc/liter]

Zone (See figure 1)	January 1–February 1	February 15–March 15	April 1–May 1	May 15–June 15	July 1–August 1	August 15–September 15	October 1–November 1	November 15–December 15
1. Northern England	[a]—	—	—	—	—	—	[b]6.8	[b]6.8
2. Northwest England	6.7	5.5	6.7	6.4	5.8	5.0	5.2	6.4
3. East & East Midlands	—	—	—	—	—	—	[b]3.7	[b]3.7
4. West Midlands	—	—	—	—	—	—	[b]5.2	[b]5.2
5. Wales	9.4	9.0	10.4	10.01	8.4	8.2	10.4	10.5
6. South & Southeast England	—	—	—	—	—	—	[b]4.2	[b]4.2
7. Midwestern England	6.6	5.1	5.7	6.0	4.6	5.7	5.5	5.6
8. Far Western England	—	—	—	—	—	—	[b]8.8	[b]8.8
9.1 Southwest Scotland	8.4	8.6	9.2	9.2	9.8	8.4	10.0	7.4
9.2 North & East Scotland	7.4	7.4	6.9					
10. Northern Ireland	11.0	10.8	11.4	10.8	9.0	9.6	9.6	11.6
Remainder of England	[b]6.3	[b]6.3	[b]6.4	[b]6.4	[b]6.2	[b]6.2		
Production weighted mean for latest 12 months.		6.93		6.58		6.65		6.82

[a] Dash indicates sample composited with 4 other sections. Analysis is reported as "Remainder of England."
[b] Analysis covers 2 time periods.

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
April 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network, operated in cooperation with State and local agencies, commenced operations in October 1957 (*1*). By the end of April 1962, 108 stations located on major waterways used for public water supply, propagation of fish and wildlife, and recreational, industrial, and agricultural purposes were submitting water samples for analyses of plankton population, organic chemicals, stream flow data, chemical, biological, and physical quality, and radioactivity (*2, 3*). Samples are taken weekly, monthly, or continually, depending on the type of analysis and the degree of water quality.

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment procedures (*4*). Naturally-occuring radioactive substances in the environment are the source of essentially all the alpha activity, while contamination from man-made sources is the major contributor of beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples according to standard procedures (*5, 6*).

For the first two years, alpha determinations were reported generally on composites of more than one weekly sample. As of January 1960, the policy was established that analyses were to be done weekly for the first operating year of each new station. At some stations on the Colorado and Animas Rivers, determinations were done on weekly samples or semimonthly on 2- or 3-week composites. The remainder of the stations were scheduled so that each station made one gross alpha determination per month. Beginning with November 1961, gross alpha determinations have been made on one sample from each station each month, unless there is evidence of alpha activity in excess of background levels. In the latter instance, an alpha determination has been made on a weekly or biweekly basis, depending on the particular station.

For the first two years of the network operations, beta determinations were made on weekly samples. Since January 1959, a portion of each sample from all stations in the network has been composited into a 3-month station sample

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in μμc/liter]

Station	Quarter ending Dec. 31, 1961	April 1962					
	Strontium-90	Beta Activity			Alpha activity		
	Total	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	—	13	8	21	—	—	—
Animas River: Cedar Hill, N. Mex	0.9	71	30	101	17	1	18
Apalachicola River: Chattahoochie, Fla	—	30	24	54	1	0	1
Arkansas River:							
Coolidge, Kansas	1.0	19	62	81	2	15	17
Ponca City, Okla	—	21	54	75	—	—	—
Pendleton Ferry, Ark	—	87	37	124	2	2	4
Big Horn River: Hardin, Mont	—	47	34	81	9	4	13
Big Sioux River: Sioux Falls, So. Dak	1.2	26	74	100	2	2	4
Chattahoochie River: Atlanta, Ga	0.3	15	8	23	0	0	0
Clear Water River: East Lewiston, Idaho	0.3	19	10	29	1	0	1
Colorado River:							
Loma, Colo	—	86	51	137	10	6	16
Boulder City, Nev	1.8	5	18	23	0	7	7
Parker Dam, Calif	—	0	13	13	0	5	5
Yuma, Ariz	—	17	32	49	—	—	—
Columbia River:							
Wenatchee, Wash	0.7	2	9	11	—	—	—
Pasco, Wash	—	72	237	309	—	—	—
McNary Dam, Oreg	—	50	210	260	0	1	1
Connecticut River:							
Northfield, Mass	—	29	21	50	—	—	—
Wilder, Vt	3.7	12	20	32	0	0	0
Cumberland River: Clarksville, Tenn	0.9	—	—	—	—	—	—
Delaware River:							
Philadelphia, Pa	—	23	24	47	—	—	—
Trenton, New Jersey	0.7	10	19	29	0	0	0
Martins Creek, Pa	—	13	16	29	0	0	0
Escambia River: Century, Fla	—	39	27	66	—	—	—
Great Lakes:							
Buffalo, N. Y	0.8	12	16	28	0	0	0
Detroit, Mich	—	3	11	14	0	0	0
Port Huron, Mich	—	7	7	14	—	—	—
Sault Ste. Marie, Mich	—	2	3	5	—	—	—
Gary, Ind	0.1	10	6	16	0	0	0
Duluth, Minn	0.1	2	4	6	0	0	0
Hudson River: Poughkeepsie, N. Y	2.5	—	—	—	—	—	—
Illinois River:							
Grafton, Ill	—	110	57	167	13	0	13
Peoria, Ill	—	28	39	67	—	—	—
Kanawha River: Winfield Dam, W. Va	—	7	15	22	—	—	—
Klamath River: Copco, Oreg	1.2	18	28	46	—	—	—
Little Miami River: Cincinnati, Ohio	0.6	7	37	44	1	0	1
Mississippi River:							
St. Paul, Minn	—	40	66	106	0	1	1
Dubuque, Iowa	—	44	22	66	2	0	2
Burlington, Iowa	—	58	37	95	9	0	9
E. St. Louis, Ill	—	48	42	90	3	0	3
Cape Giraudeau, Mo	—	66	40	106	12	2	14
Delta, La	—	69	38	107	3	1	4
New Orleans, La	—	78	26	104	4	1	5
Vicksburg, Miss	—	56	31	87	2	<1	2
Missouri River:							
Williston, N. Dak	—	38	19	57	—	—	—
Bismarck, N. Dak	—	14	25	39	1	4	5
Yankton, S. Dak	2.5	64	82	146	—	—	—
Omaha, Nebr	—	38	63	101	—	—	—
St. Joseph, Mo	—	254	49	303	—	—	—
Kansas City, Kans	—	277	57	334	—	—	—
Missouri City, Mo	—	164	39	203	19	2	21
St. Louis, Mo	2.1	124	48	172	—	—	—
Monongahela River: Pittsburgh, Pa	—	4	13	17	<1	<1	1
North Platte River: Henry, Nebr	1.3	17	50	67	1	31	32
Ohio River:							
East Liverppol, Ohio	—	11	25	36	2	0	2
Huntington, W. Va	—	32	19	51	—	—	—
Cincinnati, Ohio	—	55	17	72	3	0	3
Louisville, Ky	—	46	16	62	4	1	5
Evansville, Ind	—	46	15	61	—	—	—
Cairo, Ill	—	158	14	172	14	0	14
Ouachita River: Bastrop, La	0.7	40	52	92	0	<1	<1
Platte River: Plattsmouth, Nebr	—	83	54	137	16	6	22
Potomac River:							
Williamsport, Md	0.9	12	14	26	0	0	0
Great Falls, Md	—	18	16	34	—	—	—
Rainy River:							
Baudette, Minn	—	2	14	16	1	0	1
International Fls, Minn	—	2	12	14	0	0	0
Red River, South:							
Alexandria, La	—	124	46	170	6	0	6
Denison, Tex	—	29	27	56	1	1	2
Rio Grande River:							
Alamosa, Colo	—	29	26	55	1	2	3
El Paso, Tex	—	39	22	61	—	—	—
Laredo, Tex	—	13	45	58	1	3	4
Brownsville, Tex	—	3	27	30	—	—	—

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in μμc/liter]

Station	Quarter ending Dec. 31, 1961	April 1962					
	Strontium-90	Beta Activity			Alpha activity		
	Total	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Roanoke River: John H. Kerr Resr. & Dam, Va.	—	36	20	56	<1	0	<1
Sabine River: Ruliff, Tex.	—	23	31	54	—	—	—
San Juan River: Shiprock, N. Mex.	—	123	26	149	14	2	16
St. Lawrence River: Massena, N. Y.	1.6	16	20	36	1	0	1
Schuylkill River: Philadelphia, Penn.	—	9	15	24	—	—	—
Savannah River: Port Wentworth, Ga.	—	16	27	43	0	0	0
Shenandoah River: Berryville, Va.	0.2	30	13	43	1	0	1
Snake River:							
Wawawai, Wash.	—	12	14	26	—	—	—
Payette, Idaho	—	30	26	56	1	2	3
South Platte River: Julesburg, Colo.	—	40	46	86	3	19	22
Susquehanna River:							
Sayre, Pa.	—	30	15	45	—	—	—
Conowingo, Md.	—	26	16	42	3	0	3
Tennessee River:							
Lenoir City, Tenn.	—	13	14	27	0	0	0
Chattanooga, Tenn.	0.5	24	58	82	1	0	1
Pickwick Landing, Tenn.	—	31	38	69	0	0	0
Tombigbee River: Columbus, Miss.	0.2	—	—	—	—	—	—
Truckee River: Farad, Calif.	—	28	15	43	1	0	1
Verdigris River: Nowata, Okla.	—	20	40	60	0	2	2
Yakima River: Richland, Wash.	—	16	11	27	<1	<1	1
Yellowstone River: Sidney, Mont.	—	46	33	79	—	—	—

for measurement of strontium–90 (*7*). Beginning January 1960, analyses were performed weekly for the first operating year of each new station. Weekly analyses were to be continued indefinitely for all stations which may be affected by waste discharges from nuclear installations. Where stations have been operated for more than 1 year, semimonthly determinations on composites of 2 or 3 weekly samples were performed when beta activity was found to be above background. Monthly determinations on composites of all samples received from a station during the month were conducted on samples from streams where beta activity was at background levels. Since September 1961, gross beta determinations have been made on all samples collected.

The data reported in table 1 represent the average of all data reported for the periods indicated. The reported strontium–90 data are the results of determinations on 3-month composite samples for the quarter ending in the month shown.

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(*4*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association, 53*:704 (June 1961).

(*5*) Setter, L. R., J. E. Regnier, and E. A. Diephaus: Radioactivity of Surface Waters in the United States, *Journal of the American Water Works Association, 51*:1377 (November 1959).

(*6*) Robert A. Taft Sanitary Engineering Center, Public Health Service: Radionuclide Analysis of Environmental Samples, Technical Report, R59–6 (1959).

(*7*) Straub, C. P., L. R. Setter, A. Goldin, and P. F. Hallbach: Strontium–90 in Surface Waters in the U.S., *Journal of the American Water Works Association, 52*:756 (June 1960).

Radionuclide Analyses of Coast Guard Water Supplies

October 1961–April 1962

U.S. Coast Guard and Division of Radiological Health, Public Health Service

From 1957 through 1960, monthly samples of several U.S. Coast Guard light station rain water cistern supplies were routinely analyzed for beta activity by the Robert A. Taft Sanitary Engineering Center (*1, 2*). Due to the resultant low radioactivity concentrations two years after the 1958 cessation of nuclear weapons testing, this sampling procedure was terminated.

Since October 1961, drinking water samples have been obtained from Coast Guard Loran Stations in Alaska. In most cases, these samples are collected from small artificial impoundments or lakes. The sampling sites are shown in figure 1.

The radionuclide analyses reported in table 1 were performed by the Southwestern Radiological Health Laboratory at Las Vegas, Nevada.

REFERENCES

(*1*) Straub, C. P.: Statement on New Data on Uptake in Milk, Food, and Human Bone, *Joint Committee on Atomic Energy Hearings on Fallout From Nuclear Weapons Tests, 2*:990 (May 1959).

(*2*) U.S. Coast Guard: Analyses of Cistern Water, *Radiological Health Data*, June 1960, July 1960, and August 1961.

TABLE 1.—RADIONUCLIDES IN WATER SAMPLES FROM U. S. COAST GUARD LORAN STATIONS, OCTOBER 1961–APRIL 1962

[Concentrations in $\mu\mu c$/liter]

Alaskan location	Collection date	Gross alpha	Gross beta	Sr^{90}	Ra^{226}	I^{131}	Ba^{140}	Cs^{137}	Zr^{95}
Adak	Dec. 14, 1961	5.8	12	1.5	[a] ND	ND	ND	ND	ND
	Jan. 2, 1962	12.2	40	0.9	0.1	40	40	ND	20
	Feb. 13, 1962	0.7	11	0.3	0.2	ND	20	ND	ND
	Mar. 20, 1962	ND	28	[b]—	—	ND	15	ND	ND
Attu	Dec. 22, 1961	ND	51	0.4	ND	30	30	10	30
	Jan. 3, 1962	3.4	85	1.2	0.8	ND	105	ND	45
	Feb. 13, 1962	ND	80	1.7	ND	ND	45	ND	20
	Mar. 26, 1962	0.7	40	1.7	0.1	ND	25	5	ND
Biorka	Dec. 14, 1961	1.5	137	3.4	0.3	ND	80	ND	50
	Jan. 11, 1962	0.6	134	0.9	ND	ND	135	ND	85
	Feb. 13, 1962	ND	173	0.9	0.4	ND	80	ND	70
	Mar. 23, 1962	2.1	156	0.9	ND	ND	110	ND	120
	Apr. 22, 1962	ND	122	0.6	—	ND	ND	ND	8[illegible]
Cape Sarichef	Dec. 22, 1961	16.8	7	0.4	ND	ND	ND	ND	ND
	Jan. 3, 1962	1.0	7	0.4	ND	45	10	5	ND
	Feb. 14, 1962	1.1	13	ND	—	ND	ND	ND	ND
	Mar. 19, 1962	ND	61	—	—	ND	ND	ND	ND
	Apr. 20, 1962	ND	11	0.7	ND	ND	ND	ND	ND
Port Clarence	Oct. 1961	1.1	48	0.8	ND	ND	ND	ND	ND
	Nov. 1961	ND	12	1.1	0.3	ND	ND	ND	ND
	Mar. 19, 1962	ND	18	—	0.4	ND	ND	ND	ND
	Apr. 23, 1962	1.1	13	0.3	—	ND	ND	ND	ND
Sitkinak	Dec. 21, 1961	15.6	12	0.5	0.4	ND	ND	ND	ND
	Jan. 6, 1962	4.4	76	0.3	0.6	ND	60	ND	30
	Feb. 14, 1962	ND	120	1.7	ND	ND	55	ND	65
	Mar. 20, 1962	ND	53	2.0	0.3	ND	10	ND	30
	Apr. 26, 1962	ND	39	0.7	—	ND	ND	ND	15
Spruce Cape	Dec. 13, 1961	3.3	25	2.5	0.2	ND	ND	ND	ND
	Jan. 4, 1962	1.1	70	0.8	0.4	40	45	ND	ND
	Feb. 13, 1962	2.4	465	2.7	ND	ND	185	30	230
	Mar. 20, 1962	1.0	109	2.8	0.3	ND	30	ND	20
	Apr. 13, 1962	1.0	89	0.6	—	ND	15	ND	40
	Apr. 16, 1962	ND	608	6.2	—	ND	ND	ND	605

[a] ND indicates radionuclide not detectable.
[b] Dash indicates result not reported.

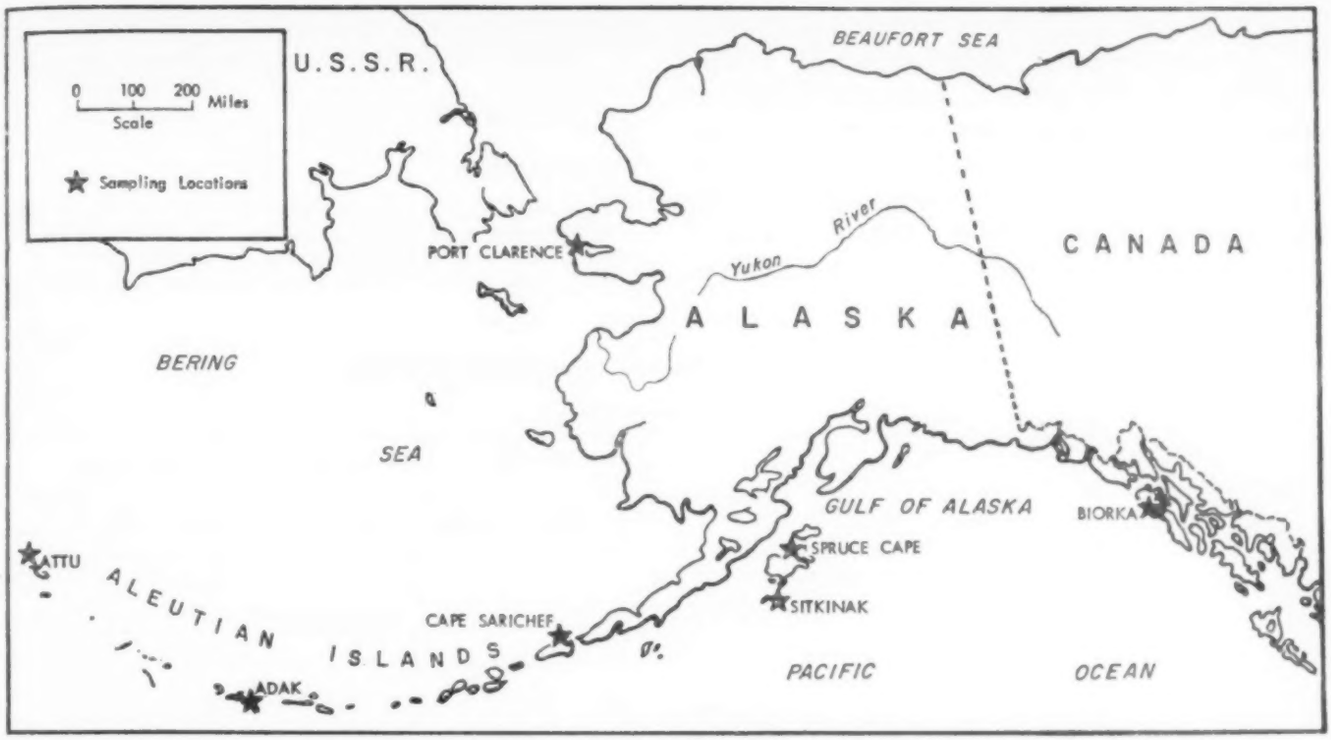

FIGURE 1.—COAST GUARD LORAN STATION WATER SAMPLING LOCATIONS

Radioactivity in Drinking Water

DRINKING WATER ANALYSIS PROGRAM 1961

Division of Environmental Engineering and Food Protection, Public Health Service

The Water Section Activity of the Interstate Carrier Branch, Division of Environmental Engineering and Food Protection, PHS, has gathered extensive data on the radioactivity content of water supplies used on interstate carriers such as trains, airplanes, ships, and other conveyances operating in interstate commerce. This work has several objectives, among which are:

1. to determine radioactivity content of interstate carrier water supplies for comparison with the revised Public Health Service Drinking Water Standards (*1, 2*);
2. to establish the background level as the basis with which to compare future results from the supplies sampled; and
3. to obtain data for study in connection with the occurrence of certain chronic diseases.

Beginning in November 1960, the project is a continuing one under which it is planned ultimately to sample the 850 U.S. water supplies used by interstate carriers. In many instances, there are several sources for a municipality and each is sampled. When the present water supply sampling for the second group of cities is completed, another group of about 100 cities will be chosen.

Each sample is a 4-liter composite of three 270-ml aliquots a day obtained during a two-week period. The gross alpha, gross beta, and strontium–90 analyses are performed at the Southeastern, Northeastern, and Southwestern Radiological Health Laboratories, operated by the Division of Radiological Health. Table 1 presents partial data from the second sampling.

Previous coverage in *Radiological Health Data*:

Period	Issue
1961	*May 1962*
1960 and 1961	*August 1962*

REFERENCES

(*1*) Public Health Service: Drinking Water Standards, 1962 Revision, PHS Regulations, (March 6, 1962).

(*2*) Drinking Water Standards for Radioactivity, *Radiological Health Data*, *3*:156–7 (May 1962).

TABLE 1.—RADIOACTIVITY IN DRINKING WATERS

[Concentrations in μμc/liter]

Station		Population served	Date sampled	Strontium–90	Alpha Activity			Beta activity		
City	State			Total solids	Suspended	Dissolved	Total	Suspended	Dissolved	Total*
Mobile	Ala.	202,779	11/16–12/2/61					<3.0	6.3	<9.3
Montgomery		134,393								
Court St. Pump Sta			5/30–6/13/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Day St. Pump Sta			5/31–6/15/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
TVA Widows Creek			6/7–6/22/61	1.1				<3.0	37.0	40.0
Tampa	Fla.	274,970	4/25–5/9/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Atlanta	Ga.	487,455								
Chattahoochee Plant			8/15–9/1/61					<3.0	<3.0	<6.0
Hemphill Plant			8/15–8/30/61					<3.0	<3.0	<6.0
Columbus		116,779	11/14–11/28/61					<3.0	4.5	<7.5
Elkhart	Ind.	40,274	6/16–6/30/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Evansville		141,543	6/15–6/30/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Muncie		68,603	1/18–2/1/61	0.2	<0.5	<0.5	<1.0	<2.6	<2.6	<5.2
Washington		10,846	6/13–6/21/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Ashland	Ky.	31,283	1/26–2/9/61	0.1		<0.5			<2.6	
Paducah		34,479	11/2–11/17/60					<1.0	6.8	7.8
Louisville		390,639	6/14–6/28/61		<0.5	<0.5	<1.0	<3.0	3.2	<6.2
Portland	Maine	72,566	3/20–4/3/61		<0.5	<0.5	<1.0	<3.0	3.9	<6.9
Ann Arbor	Mich.	67,340	4/20–5/6/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Greenville	Miss.	41,502	1/12–1/27/61	0.5	<0.5	<0.5	<1.0	<2.6	<2.6	<5.2
Jackson		144,422	6/1–6/15/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Vicksburg		29,130	2/15–3/2/61	0.6		<0.5			4.3	
Charlotte	N. C.	201,564								
Hoskins Filter Plant			3/30–4/14/61	1.0	<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Vest Station			3/30–4/14/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Raleigh		93,931	4/10–4/24/61	1.0	<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Winston-Salem		111,135	2/14–3/1/61	0.2		<0.5			<2.6	
Akron	Ohio	290,351	8/18–9/1/61					3.6	<3.0	<6.6
Lancaster	Pa.	61,055								
Conestoga Plant			7/13–7/27/61					<3.0	<3.3	<6.3
Susquehanna Plant			8/29–9/12/61					<3.0	<3.0	<6.0
Charleston	S. C.	65,925	1/10–1/25/61					<3.0	<3.0	<6.0
North Augusta		10,348	9/4–9/17/61					<3.0	<3.0	<6.0
Chattanooga	Tenn.	130,009	7/12–7/28/61	3.2				<3.0	45.0	48.0
Clarksville		22,021	7/6–7/24/61		<0.5	<0.5	<1.0	<3.0	<3.0	<6.0
Knoxville		111,827	8/18–9/1/61					<3.0	<3.0	<6.0
Huntington	W. Va.	83,627	12/9–12/27/61	0.7				<1.0	<2.2	<3.2

* Where "less than" values comprise not more than 10 percent of a total, the "less than" sign is not shown with the total.

SECTION V.—OTHER DATA

Whole Body Counting

Whole body counters are being applied where the detection of low levels of radioactivity in the human body is important, as, for example in the evalution of hazards to radiation workers and the general population. These instruments are also used in human physiological and pathological investigations as well as in studies related to counter design for special purposes. Discussion and presentation of whole body counting results in previous issues of *RHD* have been limited to medical research programs employing thallium-activated sodium iodide crystals or liquid scintillation solutions. As other whole body counting data become available, they will be published.

CESIUM–137 IN MAN
March 1962 through May 1962

U.S. Army Medical Research Unit, Landstuhl, Germany

In 1955, cesium–137 was first detected in man by the Argonne National Laboratory. It emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracel' larly, the cesium–137 levels are usually expressed in micromicrocuries per gram of potassium. The whole body counting facility at the Medical Research Unit, Landstuhl, Germany, in its program for measuring the cesium–137 levels in man, utilizes a liquid scintillation counter (*1*).

TABLE 1.—ASSAYS PERFORMED AT U.S. ARMY MEDICAL RESEARCH UNIT, LANDSTUHL, GERMANY

Date	Number of subjects	Residence	Cesium-137 $\mu\mu$c/gK (average)	Percent MPBB*
March 1962	250	West Germany	27	0.13
April 1962	168	West Germany	28	0.13
May 1962	418	West Germany	34	0.16

* Percent maximum permissible body burden was calculated using 3 μc of cesium-137 as the general population maximum permissible whole body burden and 140 grams of potassium in the body of the "standard man." (See pp. 187 and 192 of Radiological Health Handbook, Office of Technical Services, U. S. Department of Commerce (1960), price $3.75.)

Previous coverage in *Radiological Health Data*:

Period	Issue
1958 and 1959	*October 1960*
1959 and 1960	*January 1961*
1958, 1959, and 1960	*April 1961*
First quarter 1961	*July 1961*
Second quarter 1961	*October 1961*
Third quarter 1961	*January 1962*
First quarter 1962	*August 1962*

REFERENCE

(*1*) *Radiological Health Data 2*:192–4 (April 1961).

External Gamma Activity

RADIATION SURVEILLANCE NETWORK
July 1962

Division of Radiological Health, Public Health Service

Daily measurements of external gamma radiation are made at stations of the Radiation Surveillance Network to assure detection of any substantial deviations from normal background levels. Portable Geiger-Mueller survey instruments are used to obtain measurements at three feet above the ground surface. July 1962 data reported in table 1 are characteristic of individual station observations which in recent years have defined the range of background values.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, JULY 1962

Station location		Average (mr/hr)	Station location		Average (mr/hr)
City	State		City	State	
Adak	Alaska	0.01	Minneapolis	Minn	0.01
Anchorage	Alaska	0.01	Jackson	Miss	0.01
Attu	Alaska	0.01	Pascagoula	Miss	0.01
Fairbanks	Alaska	0.01	Jefferson City	Miss	0.01
Juneau	Alaska	0.01	Helena	Mont	0.03
Kodiak	Alaska	0.01	Lincoln	Nebr	0.08
Nome	Alaska	0.01	Las Vegas	Nev	0.01
Point Barrow	Alaska	0.01	Concord	N. H	—
St. Paul Island	Alaska	0.01	Trenton	N. J	0.02
Phoenix	Ariz	0.01	Santa Fe	N. Mex	0.04
Little Rock	Ark	0.01	Albany	N. Y	0.02
Berkeley	Calif	0.01	Buffalo	N. Y	0.01
Los Angeles	Calif	0.02	New York	N. Y	—
Denver	Colo	0.02	Gastonia	N. C	0.02
Hartford	Conn	0.01	Bismarck	N. D	0.01
Dover	Del	0.01	Columbus	Ohio	0.01
Washington	D. C	0.04	Painesville	Ohio	0.01
Jacksonville	Fla	0.01	Oklahoma City	Okla	0.02
Miami	Fla	0.01	Ponca City	Okla	0.02
Atlanta	Ga	[a]—	Portland	Ore	0.02
Agana	Guam	0.01	Harrisburg	Pa	0.02
Honolulu	Hawaii	0.01	San Juan	P. R	0.01
Boise	Idaho	0.01	Providence	R. I	0.02
Springfield	Ill	0.01	Columbia	S. C	0.02
Indianapolis	Ind	0.01	Pierre	S. D	0.02
Iowa City	Iowa	0.01	Nashville	Tenn	0.01
Topeka	Kans	0.03	Austin	Tex	0.01
Frankfort	Ky	0.01	El Paso	Tex	0.02
New Orleans	La	0.02	Salt Lake City	Utah	0.02
Augusta	Maine	0.02	Barre	Vt	0.02
Presque Isle	Maine	0.02	Richmond	Va	0.01
Baltimore	Md	0.02	Seattle	Wash	0.02
Rockville	Md	—	Charleston	W. Va	—
Lawrence	Mass	0.02	Madison	Wis	0.01
Winchester	Mass	0.01	Cheyenne	Wyo	0.02
Lansing	Mich	0.02			

[a]Dash indicates no data received.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 21 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Hanford Atomic Products Operation, Lawrence Radiation Laboratory, and Los Alamos Scientific Laboratory.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in National Bureau of Standards "Handbook 69." The MPC values applicable to the following reports are given in table 1.

To avoid any possible misunderstandings in the use of the term "Maximum Permissible Concentrations," the Federal Radiation Council (FRC) has recommended the term "Radioactivity Concentration Guide" (RCG) for the use of Federal Agencies. Although FRC has not published a table of RCG values, several AEC installations, have adopted FRC nomenclature and use the NCRP published values or have derived their own RCG values on the basis of Radiation Protection Guides (RPG's) such as 500 mrem/year total body exposure. For a more detailed description of the meaning and use of the RCG, the reader is referred to FRC Report No. 2.* The RPG's in terms of total intake in $\mu\mu c$/day averaged over a 1-year period which are recommended in FRC Report No. 2 are as follows: the upper limits of Range II for radium–226, iodine–131, strontium–90 and strontium–89 are 20, 100, 200, and 2000 respectively.

In the following reports, the use of nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when con-

* Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., price 20 cents.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radionuclide or mixture of unknown nuclides	Environmental MPC's	
		Water ($\mu\mu c$/liter)	Air ($\mu\mu c/m^3$)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{225}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, Pu^{241} are not present[a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present[a]	—	100
8	Arsenic-76	20,000	3,000
9	Copper-64	200,000	40,000
10	Chromium-51	2,000,000	80,000
11	Iodine-131 (FRC Guide: 100 $\mu\mu c$/day)	2,000	300
12	Manganese-56	100,000	20,000
13	Neptunium-239	100,000	30,000
14	Phosphorus-32	20,000	2,000
15	Plutonium-239	5,000	0.06
16	Silicon-31	200,000	30,000
17	Sodium-24	30,000	5,000
18	Strontium-90	100	10
19	Uranium-natural	20,000	2

[a] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to recent AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

centrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justfy a less restrictive value. References to table 1 will be made to designate the appropriate MPC's reported by the laboratories.

HANFORD ATOMIC PRODUCTS OPERATION

Third and Fourth Quarters 1961

General Electric Company
Richland, Washington

The Hanford Atomic Products Operation (HAPO) is located in a semi-arid region of southeastern Washington. The project is a five-hundred square mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities, and research and development laboratories.

Various radioactive wastes which result from plant operations are disposed through controlled releases to the atmosphere, ground, and the waters of the Columbia River. A primary responsibility of plant personnel is to monitor and safeguard against any effects these wastes may have on the 80,000 residents of Richland, Pasco, Kennewick, and other communities in the vicinity of the project.

The monitoring program includes surveillance of the atmosphere, vegetation, fish and wildlife, milk and agricultural produce, and the waters of the Columbia River and Pacific Ocean. Further measurements are made of external radiation and possible ground contamination from burial pits.

Atmosphere

Gaseous wastes are released to the atmosphere through 200-foot stacks after removal of most radioactive material originally present.

Hanford project maintains air sampling stations at Benton City, Kennewick, Pasco, Richland, Seattle, Spokane, Walla Walla, and Yakima, Washington; Meacham and Klamath Falls, Oregon; Boise and Lewiston, Idaho; and Great Falls, Montana. Sample filters are changed weekly and sent to Hanford for analyses. Third and fourth quarter 1961 summaries of beta concentration in these filters are presented in table 2.

TABLE 2.—AVERAGE AIR-BORNE BETA ACTIVITY IN SELECTED PACIFIC N. W. LOCATIONS, HAPO

[Average concentrations in $\mu\mu c/m^3$]

Sampling location	Third Quarter 1961		Fourth Quarter 1961	
	No. of samples	Beta	No. of samples	Beta
Richland, Wash	13	0.56	14	6.10
Boise, Iadho	11	0.44	13	8.70
Hanford project	13	0.54	14	4.70
Seattle, Wash	13	0.18	14	3.38
Meacham, Ore	13	0.15	13	4.14

Releases of iodine–131 are of particular interest and routine measurements are made at several locations around the plant area. Total stack releases averaged 0.78 and 0.55 curies per day for the third and fourth quarters, respectively, and the concentrations in the local environmental air are shown in table 3.

TABLE 3.—IODINE-131 IN AIR AT PERIMETER COMMUNITIES, HAPO

[Average concentration in $\mu\mu c/m^3$]

Station	Third Quarter 1961		Fourth Quarter 1961	
	No. of samples	I^{131}	No. of samples	I^{131}
Richland	13	0.011	13	0.054
North Richland	13	0.014	13	0.118
Benton City	12	0.022	12	0.026
Pasco	13	0.015	11	0.107

Water

Hanford's eight production reactors are cooled by treated water pumped from the Columbia River. After the water passes through the reactors, it is returned to the river. Some radioactivity results from neutron activation of impurities remaining in the treated water and is discharged in the effluent. The major part (90 percent) of this radioactive material consists of Mn^{56}, Cu^{64}, Na^{24}, Cr^{51}, Np^{239}, As^{76}, and Si^{31}. Although the presence of Zn^{65}, P^{32}, and certain other radionuclides are of interest, they are found only in minor quantities. River water samples are taken at Hanford Ferry, Pasco, and Vancouver to be analyzed for several radionuclides. Selected results are presented in table 4.

TABLE 4.—SELECTED RADIONUCLIDES IN COLUMBIA RIVER WATER, HAPO

[Average concentration in μμc/liter]

Sampling location	Third Quarter 1961			Fourth Quarter 1961		
	Na^{24}	P^{32}	Zn^{65}	Na^{24}	P^{32}	Zn^{65}
Hanford Ferry	9150	184	350	11,600	328	500
Pasco	1750	99	158	2,120	234	238
Vancouver	[a]—	22	87	—	42	<24

[a]Dash indicates no analysis.

Fish and Wildlife

Fish in the Columbia River accumulate some of the radionuclides present in water and whitefish in particular concentrate phosphorus–32 which is a major bone seeker. The average concentration of phosphorus–32 in the flesh of whitefish caught near the plant was 800 μμc/g.

Migratory waterfowl, which may have utilized the Hanford section of the Columbia River were obtained from hunters in Washington, Oregon, Idaho, and California. Analyses of 1500 of these specimens showed that only one out of thirteen contained concentrations of phosphorus–32 greater than the detection level of 50 μμc/g and the maximum concentration found was 2,600 μμc P^{32}/g.

In order to determine the kinds, number, and disposition of local fish and waterfowl harvested, a creel survey was initiated in 1961. This survey is being carried out by contract with the Washington Department of Game.

An estimated 10 pounds of whitefish per person per year for roughly 2,000 people in the Pasco-Kennewick-Richland area was used in the evaluation of population dose from fish and waterfowl: (*Editor's note:* Refer to *Radiological Health Data,* February 1962, pp. 63-4 for a graphic presentation of the estimated population dose in the Hanford vicinity for 1960. The 1961 estimates are similar.)

Milk and Agricultural Produce

There is no farming within about a 20-mile radius of the chemical separations facilities (the major local source of air-borne radionuclides), but the Ringold farms and Riverview District of Pasco, which are respectively about 15 and 30 miles downstream from the reactors, take water from the Columbia River. Some radionuclides are traced though the irrigation process into milk and produce.

Analyses of local milk for strontium–90, strontium–89, and cesium–137 indicated average concentrations which ranked among the lowest in the nation. These radionuclides result predominantly from world-wide fallout. However, phosphorus–32 and zinc–65 in milk originate from the irrigation water and the 1961 average concentrations of phosphorus–32 in milk from dairy farms in the Ringold and Pasco areas were 725 and 622 μμc/liter respectively. The zinc–65 average concentration was 725 μμc/liter at Ringold and 518 μμc/liter at Pasco.

Assays of local milk for iodine–131 during the third quarter revealed little contamination and the average was less than 60 μμc/liter. Fallout after the resumption of nuclear testing caused a brief rise in iodine–131 and on November 2, 1961 the maximum local concentration reached 1,500 μμc/liter. However, the rapid decay rates of iodine–131 and the use of dry winter feeds allowed the concentration in milk to drop to about 2 μμc/liter by late December.

Measurements were made on samples of pasture grass to estimate the iodine–131 intake from leafy vegetables. Prior to the arrival of world-wide fallout, the average concentration was 0.2 μμc/g; after the arrival of fallout, external sources of nuclides introduced a large source of error which interfered with estimations of exposure from plant emissions.

External Radiation

Ionization chambers located above ground and in the Columbia River were used to estimate the combined exposure from external sources in the Hanford area. Aboveground measurements indicated an annual exposure in 1961 of about 130 mr. Virtually all of this radiation is attributable to natural background.

The presence of gamma emitters, especially Na^{24}, in reactor effluent causes a higher exposure rate in the river. The average dose in the water near Richland was about 2.5 mr/day and near Kennewick about 0.9 mr/day. This would mean that a person swimming or boating in the river for 240 hours per year would receive about 25 mr of exposure.

Ground Releases

Solid wastes are packaged and buried in trenches; "high level" liquid wastes which normally contain activity of 10^{11} μμc/liter or more are neutralized and stored in concrete tanks lined with steel; "intermediate level wastes" containing activity between $5x10^4$ and 10^{11} μμc/liter are sent to underground cribs from which waste can percolate into the soil; and "low level wastes" containing less than $5x10^4$ μμc/liter are sent to depressions in the ground where they form surface ponds.

To monitor the extent to which radionuclides reach the ground water, wells have been drilled in crib and tank storage areas. Figure 1 shows the probable extent and concentration of radioactive materials in ground water.

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first and second quarters 1960	*May 1961*
Third and fourth quarters 1960 and first and second quarters 1961	*February 1962*

LAWRENCE RADIATION LABORATORY
Third and Fourth Quarters 1961

University of California
Berkeley, California
Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located adjacent to the campus of the University of California. The technical facilities include a 6.3 Bev proton accelerator, a 700 Mev cyclotron, a linear accelerator of 10 Mev per nucleon, and various chemistry and physics laboratories.

The environmental sampling program includes atmospheric samples of stack releases, local area air, perimeter air, and rain or dry deposition; and water samples of building wastes, tap water, surface water, and off-site creeks. Analyses are made for alpha and beta concentrations.

Approximately 30 to 40 stacks, mostly laboratory hood exhausts, were sampled during the 3rd and 4th quarters. The normal sampling period was one week. Filters were then counted for alpha and beta activity.

Outdoor air samples were taken daily or weekly at three locations within the laboratory area and at four locations along the University of California property line. One additional sampling site is now located in downtown Berkeley to provide background information on contamination from weapons testing.

A summary of 3rd and 4th quarter air monitoring data is presented in table 5.

TABLE 5.—ATMOSPHERIC MONITORING, BERKELEY SITE

[Average concentration in μμc/m³]

Sampling locations	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Stacks	498	0.017	0.60	404	0.031	5.30
Local air	70	0.002	0.82	85	<0.002	8.43
Perimeter air	[a]16	<0.002	2.40	47	<0.002	8.29
Reference sample[b]	—	—	—	32	0.003	6.35

[a] Predominantly September samples.
[b] Downtown Berkeley location began operation November 1961.

Rain and/or dry deposition was sampled at irregular intervals at one location during the 3rd quarter, but beginning with the 4th quarter the sampling program was increased to provide weekly data at 7 sites. Fourth quarter deposition averages may be found in table 6.

TABLE 6.—TOTAL DEPOSITION AT BERKELEY SITE FOURTH QUARTER 1961

[Deposition in mμc/m²]

Sampling location	No. of samples	Alpha	Beta
Local area			
Building 4	16	0.170	467
All others	24	0.024	153
Perimeter	47	0.034	168

Acid wastes from two chemical laboratory buildings were sampled and analyzed before dilution and discharge through the main sewer system. The sewage data in table 7 were estimated from the results of the above analyses. It is assumed that these two buildings are the only significant sources of radioactive liquid wastes.

Surface water was sampled weekly or biweekly from two small streams on the laboratory site. Six nearby off-site creeks were also sampled every two or four weeks depending on the relative distance from the laboratory.

Tap water samples were taken approximately every week and the analyses results are summarized in table 7 with the above water data.

TABLE 7.—WATER MONITORING, BERKELEY SITE

[Average concentration in μμc/liter]

Type of sample	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Tap water	10	0.04	2.0	11	0.04	5.1
On site streams	24	0.12	7.9	24	0.14	21.1
Off site streams	33	0.10	2.6	30	0.09	12.5
Sewage (estimated)	—	0.09	3.6	—	0.15	10.3

Livermore Site

The Livermore site of LRL is located 3 miles east of Livermore, California. Technical facilities include a small cyclotron, a two megawatt swimming pool reactor, and physics and chemistry operations associated with a weapons development program. The laboratory also operates Site 300 which is physically located about 20 miles southeast of Livermore.

Environmental survey samples are collected for the purpose of detecting changes from the normal concentrations of radionuclides that could be attributed to operations at the laboratory. Samples include air particulate, soil, water, and sewage plant products.

Air particulate samples are collected continuously from 11 sites within 5 miles of the LRL. Filters are changed weekly and analyses made for alpha and beta activity. Third and fourth quarter results of these locations are summarized in table 8. The third quarter averages of alpha and beta activity at Site 300 were <0.0014 and <0.0032 $\mu\mu c/m^3$, respectively.

TABLE 8.—AIR MONITORING, LIVERMORE SITE

[Average concentration in μμc/m³]

Distance from lab.	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
0.5–1.0 miles	13	0.012	0.039	44	0.006	3.4
2–5 miles	13	0.012	0.045	135	0.007	3.2

Ground water samples are collected to insure that radioactivity is not entering underground water sources from laboratory operations. This underground water is the sole source of domestic water for the Livermore area and is also used for irrigation. All water used at Site 300 is drawn from an underground source which is geologically separated from Livermore water. Table 9 summarizes the quarterly results.

TABLE 9.—RADIOACTIVITY IN WELL WATER AT LIVERMORE SITE

[Average concentration in μμc/liter]

Sample source	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
LRL Site	65	<15	<100	51	8.2	68
Site 300	65	<15	<100	30	8.2	68
Livermore (city)	6	<15	<100	8	8.2	68

Numerous soil samples are taken from around the Livermore area to maintain a further check on air-borne radioactive particulates. Sewage from the laboratory and Livermore is processed into dry sludge used for agricultural soil conditioner. Therefore, samples are taken at the Livermore Sewage Treatment Plant to assure that the concentration of radioactivity in the sludge is no higher than the normal concentration in the soil. Results of soil and sewage sludge sampling are presented in table 10.

TABLE 10.—RADIOACTIVITY IN SOIL AND SLUDGE, LIVERMORE SITE

[Average concentration in μμc/g]

Sample	Third Quarter 1961			Fourth Quarter 1961		
	No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Soil	39	<7.7	<52	54	4.5	38
Sludge*	10	<7.7	<52	3	4.5	38

*Livermore Sewage Plant.

LOS ALAMOS SCIENTIFIC LABORATORY 1960–1961

University of California
Los Alamos, New Mexico

The Los Alamos Scientific Laboratory (LASL), in cooperation with the U.S. Geological Survey, conducts a program of environmental monitoring to determine what effect

Laboratory activities have on the local area. The Laboratory is located in an area of high elevation in northern New Mexico. The program includes air particulate sampling for alpha and beta activity, water assays for specific radioactive materials, and measurements of gamma radiation. Average annual rainfall is 18 inches and stream flow is seasonal, dependent on snow run-off and storm activity.

Radioactive wastes are released in small amounts to the atmosphere and stream beds or are buried in restricted burial areas. Disposal is governed by the geology of the area to minimize any possibility of long-lived radioactive material causing future contamination of drinking or irrigation water sources.

Air Monitoring

Daily sampling of beta activity in air at LASL showed results similar to the values reported throughout the United States. The 1961 average at the laboratory was 3.32 $\mu\mu c/m^3$. This may be compared with 4.22 $\mu\mu c/m^3$ for the 1961 average of 171 stations of the Public Health Service National Air Sampling Network.[1]

Air particulate sampling stations are also located at 24 sites throughout the area to monitor for long-lived alpha activity. Sampling is performed continuously for one week before the filters are removed and counted. The maximum reading at any station for one week during the two-year period was 0.02 $\mu\mu c/m^3$; the average was less than 0.004 $\mu\mu c/m^3$ (See table 1, line 4 for MPC).

Water Monitoring

Assays for plutonium and uranium are made on water samples taken from the Los Alamos environs including surface and ground water, supply wells, and test wells.

The Rio Grande and Rio Chama are sampled periodically. The results indicate a fairly constant uranium concentration of about 1 $\mu\mu c$/liter. Bi-monthly or semi-annual samples collected from seven intermittent surface water sources showed uranium concentrations similar to that of the river samples.

Thirteen supply wells and 8 test wells are also sampled. The majority of these wells contain the same uranium concentration as the river and surface sources. One exception is a deep supply well which has a concentration of about 10 $\mu\mu c$/liter.

No plutonium has been detected in any water sample taken from the above sources.

Gamma Radiation

Film badges are placed on stakes at approximately 100 locations throughout Los Alamos County to detect and measure any gamma radiation resulting from LASL activities. The badges are presently collected and read once each quarter.

During 1960, two stations received slightly more than 0.5 rem of gamma radiation and in 1961 readings of 7.13, 3.15, 2.00, 0.75, and 0.54 rem were obtained at five stations. However, all of these stations were immediately adjacent to a radiation facility and were located so that personnel could not have remained long enough in the area to receive an appreciable part of the total dose. The source of the above high readings was removed on December 13, 1961 and the measurements indicate that no individual of the population could have received over 0.5 rem of whole body radiation during a 12 month period.

NEVADA TEST SITE DETONATION SURVEILLANCE

Atomic Energy Commission

April 14 Event

A low yield nuclear device was detonated in an underground tunnel chamber at the Nevada Test Site on April 14, 1962. Immediately upon detonation, radioactive steam was vented from the mouth of the tunnel and from a fissure which occurred on the top of the mesa. Aircraft monitoring of the cloud indicated a heading of 20° from ground zero, and, by twenty-two minutes after detonation, the cloud had reached an altitude of 10,000 feet Mean Sea Level (MSL). The cloud held to this bearing, and it was tracked on the ground and in the air.

The U.S. Public Health Service personnel, under contract to the Atomic Energy Commission, conducted extensive off-site monitoring

[1] *Radiological Health Data* 3:113 (April 1962).

TABLE 11.—AIR MONITORING FOLLOWING THE APRIL 14, 1962 EVENT, NTS

Location	Number of people	Sampling period			Radio-isotopes	Average concentration ($\mu\mu c/m^3$)
		Duration (hr.-min.)	Ending			
			Date	Time		
Diablo	5	6–50	April 14	1650	Iodine-131	525
					Iodine-135	2,000
		14–0	April 15	0700	Iodine-131	17.3
					Iodine-133	87
					Iodine-135	[a] ND
Currant	[b] 50	24–0	April 15	0800	Iodine-131	400
					Iodine-133	2,100
					Iodine-135	ND

[a] ND means not detectable.
[b] Migrant farm population varies from 50–200 during summer and fall.

and have determined the following exposures to the off-site population:

At Diablo Maintenance Station (forty-four miles from the test site), five people were present when the cloud passed. They were wearing badges supplied on March 8, 1962. These badges were collected on April 25, 1962, and showed a total exposure of 55 to 65 mr. After subtracting the normal background dose from the total recorded, lifetime doses of approximately 28 to 38 mr were estimated as resulting from this event.

As the cloud was carried northward by prevailing winds, it arrived over Currant (population 50; 115 miles from NTS) at about H + 7½ hours. For a period of 30 minutes, the reading was above background, and the peak reading was 0.5 mr per hour. Air samples indicated the presence of slight but detectable quantities of fresh fission products, such as iodine–131, iodine–133, tellurium–132 and ruthenium–105.

Table 11 illustrates the amount of activity of radioiodine in the air monitored at populated areas. The periods of collection encompass the passage of the gaseous cloud.

May 19 Event

Following an underground nuclear detonation at the Nevada Test Site on May 19, 1962, radioactive gases were released. Gases escaped for a period of twenty minutes. These gases formed into a cloud and were carried north of the test site by the prevailing winds.

From off-site data collected, the highest measured gamma radiation in a location where people were known to be present was at Diablo, fifty-five miles north of the test site. The cloud arrived at H + 1¾ hours, with a maximum ground reading of 1.5 mr/hr at H + 2½. By H + 3½, the reading was 0.5 mr/hr, and at H + 7¾, readings were at background levels. The total exposure might have been about 1 mr, but this was considerably below the threshold of detection by the film badges worn.

Due to high surface wind speeds, this cloud was carried rapidly northward and had dispersed considerably by the time it passed to the west of Ely. Between 2:00 p.m. and 3:45 p.m., it was scarcely detectable above normal background.

Analysis of activated charcoal filters indicated the atmospheric concentrations of radioisotopes at the time of cloud passage shown in table 12.

Addenda

Additional information now is available from data collected after the March 5, 1962 event, a subsurface nuclear detonation at the Nevada Test Site that released activity to the atmosphere[a]. These data show that the highest concentrations found in air in a populated place were at Warm Springs, Nevada. The air sampler operating between 1020 and 1515 hours indicated a gross beta count of 1000 $\mu\mu c/m^3$,

[a] These data are supplemental to the material appearing in *RHD*, May 1962, page 170.

TABLE 12.—AIR MONITORING FOLLOWING THE MAY 19, 1962 EVENT, NTS

Location	Sampling period			Radio-isotopes	Average concentration ($\mu\mu c/m^3$)
	Duration (hr.-Min.)	Ending			
		Date	Time		
Tempiute	7–00	May 19	1630	Iodine-131	[a] ND
				Iodine-133	[b] —
				Iodine-135	ND
				Tellurium-132	ND
Penoyer	7–35	May 19	1635	Iodine-131	ND
				Iodine-133	3.7
				Iodine-135	6.2
				Tellurium-132	ND
Diablo	6–15	May 19	1540	Iodine-131	ND
				Iodine-133	3.2
				Iodine-135	12
				Tellurium-132	ND
Diablo	18–45	May 20	1030	Iodine-131	ND
				Iodine-133	0.69
				Iodine-135	1.40
				Tellurium-132	ND
Fallini	24–00	May 20	0615	Iodine-131	ND
				Iodine-133	ND
				Iodine-135	ND
				Tellurium-132	ND
Currant	10–45	May 20	0645	Iodine-131	516
				Iodine-133	23
				Iodine-135	18
				Tellurium-132	ND
Lund	5–30	May 19	1630	Iodine-131	ND
				Iodine-133	[b] —
				Iodine-135	ND
				Tellurium-132	ND
Ely	5–00	May 19	1400	Iodine-131	ND
				Iodine-133	ND
				Iodine-135	ND
				Tellurium-132	ND

[a] ND means not detectable.
[b] Detected but not quantitated.

16 $\mu\mu c/m^3$ of tellurium–132, 6.9 $\mu\mu c/m^3$ of iodine–131, 187 $\mu\mu c/m^3$ of iodine–133 and 275 $\mu\mu c/m^3$ of iodine–135 on the filter and 33.7 $\mu\mu c/m^3$ of iodine–133 and 73.5 $\mu\mu c/m^3$ of iodine–135 on the charcoal cartridge.

Based on dose rate readings, the estimated maximum exposure received off-site was approximately 1.7 mr to two persons at Clark's Station. (Film badges have a threshold of recording at 30 milliroentgens, and it is difficult to estimate accurately such low doses from survey meter readings.) The internal exposure due to inhalation was a small fraction of the total external exposure.

Reported Nuclear Detonations

September 1962

Summary information on announced nuclear detonations during the last month is indicated in the table below. Not all detected U.S.S.R. tests are necessarily announced by the Atomic Energy Commission. The AEC has indicated in general announcements that additional detonations have been detected in both the Fall 1961 U.S.S.R. test series and during the recent U.S.S.R. testing. The AEC announced by specific press releases 31 tests in the Fall 1961 series, and indicated in more recent press releases additional tests which brought the series' total to approximately 50. During the current U.S.S.R. testing activities, a similar reporting procedure is being used by AEC.

Radiological Health Data summarizes all available specific announcements of nuclear tests during each month preceding publication. Numbers are assigned to only those U.S.S.R. tests which have been announced since the termination of the test moratorium in 1961.

Corrections for the July 1962 Reported Nuclear Detonations: (1) U.S. test number 67 (Project Sedan) on July 6 at the Nevada Test Site was incorrectly reported as having a yield range of 1,000 kilotons; the correct yield range for this test is 100 kilotons. "Project Sedan" is part of the Commission's Plowshare Program in which peaceful uses for nuclear explosives are being explored. (2) The July 9 high altitude U.S. test has been called "Starfish" and its yield range previously given as megaton is specified as 1.4 megatons.

Test number	Location	Date (1962)	Yield range*	Type of test
REPORTED U.S.S.R. DETONATIONS				
41	Novaya Zemlya	September 2	Intermediate	Atmospheric
42	Novaya Zemlya	8	Megaton	Atmospheric
43	Novaya Zemlya	15	Low megaton	Atmospheric
44	Novaya Zemlya	16	Low megaton	Atmospheric
45	Novaya Zemlya	18	Low megaton	Atmospheric
46	Novaya Zemlya	19	Multi-megaton	Atmospheric
47	Novaya Zemlya	21	Low megaton	Atmospheric
48	Novaya Zemlya	25	30 megatons	Atmospheric
49	Novaya Zemlya	27	Less than 30 megatons	Atmospheric
REPORTED U.S. DETONATIONS				
79	Nevada Test Site	September 14	Low yield	Underground
80	Nevada Test Site	20	Low yield	Underground
81	Nevada Test Site	29	Low yield	Underground

* Low yield range has been announced as less than 20 kilotons yield; intermediate yield is in the range of 20 kilotons up to 1 megaton; and low megaton yield is in the range from 1 to several megatons.

Announcement of Current Training Activities

Public Health Service

November 1962-May 1963

Short courses, designed primarily for public health personnel interested in acquiring basic information in radiological health, are again being offered by the Division of Radiological Health, Public Health Service. These courses cover a broad range of subjects dealing with the prevention and control of radiation hazards.

Extending from one week to ten-weeks duration, courses are given at the Robert A. Taft Sanitary Engineering Center (SEC), Cincinnati, Ohio; the Radiological Health Laboratory (RHL), Rockville, Maryland; the Southwestern Radiological Health Laboratory (SWRHL), at Las Vegas, Nevada; the Southeastern Radiological Health Laboratory (SERHL), Montgomery, Alabama; and the Northeastern Radiological Health Laboratory (NERHL), Winchester, Massachusetts.

Below is a list of courses available for the remainder of the training year (course numbers in parentheses):

Nov. 5-16, 1962	Occupational Radiation Protection (212) SEC
Nov. 26-30, 1962	Radioactive Pollutants in Water (195) SEC
Nov. 26-Dec. 7, 1962	Basic Radiological Health (211) RHL
Dec. 3-7, 1962	Radionuclides in Water (222) SEC
Dec. 3-14, 1962	Basic Radiological Health (211) SERHL
Dec. 10-14, 1962	Measurement of Airborne Radioactivity (417) SEC
Dec. 10-14, 1962	Medical X-ray Protection (213) RHL
Jan. 7-Mar. 15, 1963	Engineering Aspects of Radiological Health (231) SEC
Jan. 7-18, 1963	Basic Radiological Health (211) SEC
Jan. 7-18, 1963	Medical Aspects of Radiological Health (201) RHL
Jan. 21-Feb. 1, 1963	Occupational Radiation Protection (212) SEC
Jan. 28-Feb. 8, 1963	Basic Radiological Health (211) RHL
Feb. 4-22, 1963	Environmental Radiation Surveillance (244) SEC
Feb. 25-Mar. 7, 1963	Reactor Safety and Hazards Evaluation (233) SEC
Mar. 11-15, 1963	Medical X-ray Protection (213) SEC or RHL
Feb. 11-15, 1963	Medical X-ray Protection (213) RHL
Feb. 11-22, 1963	Basic Radiological Health (211) SWRHL
Feb. 25-Mar. 1, 1963	Management of Nuclear Emergencies (234) SWRHL
Mar. 18-May 24, 1963	Engineering Aspects of Radiological Health (231) SEC
Mar. 18-29, 1963	Basic Radiological Heath (211) SEC
April 1-12, 1963	Occupational Radiation Protection (212) SEC
April 15-May 3, 1963	Environmental Radiation Surveillance (244) SEC
May 6-16, 1963	Reactor Safety and Hazards Evaluation (223) SEC
May 6-16, 1963	Basic Radiological Health (211) SEC
May 20-24, 1963	Medical X-ray Protection (213) SEC or RHL
Mar. 18-29, 1963	Basic Radiological Health (211) RHL
April 1-5, 1963	Medical X-ray Protection (213) RHL
April 15-26, 1963	Basic Radiological Health (211) RHL
April 29-May 3, 1963	Medical X-ray Protection (213) RHL
May 13-17, 1963	Radiological Health for Nurses (203) RHL
May 20-24, 1963	Radionuclides in Foods (340) SEC
To be announced	Sanitary Engineering Aspects of Nuclear Energy (225) SEC

For further information on SEC courses, contact the Chief, Training Program, Robert A. Taft Sanitary Engineering Center. Additional details on courses offered at Rockville, Maryland; Las Vegas, Nevada; Winchester, Massachusetts; and Montgomery, Alabama, are available from the Chief, Training Branch, Division of Radiological Health, 1901 Chapman Avenue, Rockville, Maryland.

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UNITS AND EQUIVALENTS

For the convenience of the *Radiological Health Data* (*RHD*) reader a selected list of units and equivalents is presented below.

Symbol	Name	Equivalent
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
ml	milliliter	
Bev	billion electron volts	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	precipitation: $\text{mm} = \frac{\mu\mu c/m^2}{\mu\mu c/\text{liter}} = \frac{\text{liter}}{m^2}$
mm	millimeter	thickness: 1/1000 meter
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 m$\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 $\mu\mu$c = 10^{-12} curies
$\mu\mu c$	micromicrocurie	1 $\mu\mu$c = 2.22 dpm

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